



# **Nuclear Humanism : The Case for Atomic Power**

Reading Time: 60 minutes

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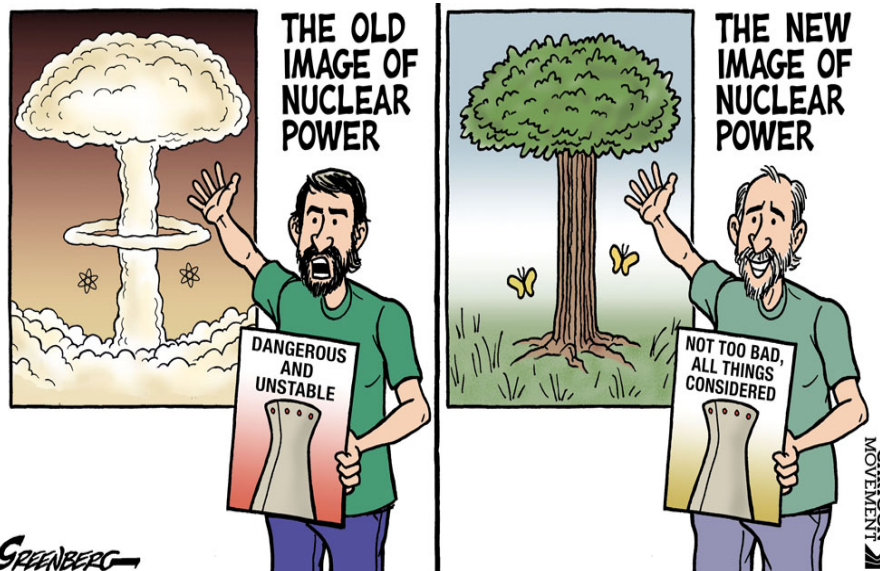
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## Part ONE: Introduction

This discussion paper is an urgent call for political actors, parties and their networks in the UK to establish a robust long-term statutory framework to create the –Ultimate Power Couple“ [1](#) a Pro-Nuclear electricity generation partnership with Wind Water & Solar renewable energy in recognition that it is the physical world, of science, maths and engineering that determines what is politically possible, [2](#) not the other way round.

When the physical evidence presented here below is honestly and dispassionately analysed, it very strongly suggests that non-Nuclear 100% Wind Water & Solar (WWS) electricity generation systems “simply won't work” – not even close to the 50+ fold increase needed to displace Big Fossil's **85%** global energy supply dominance.

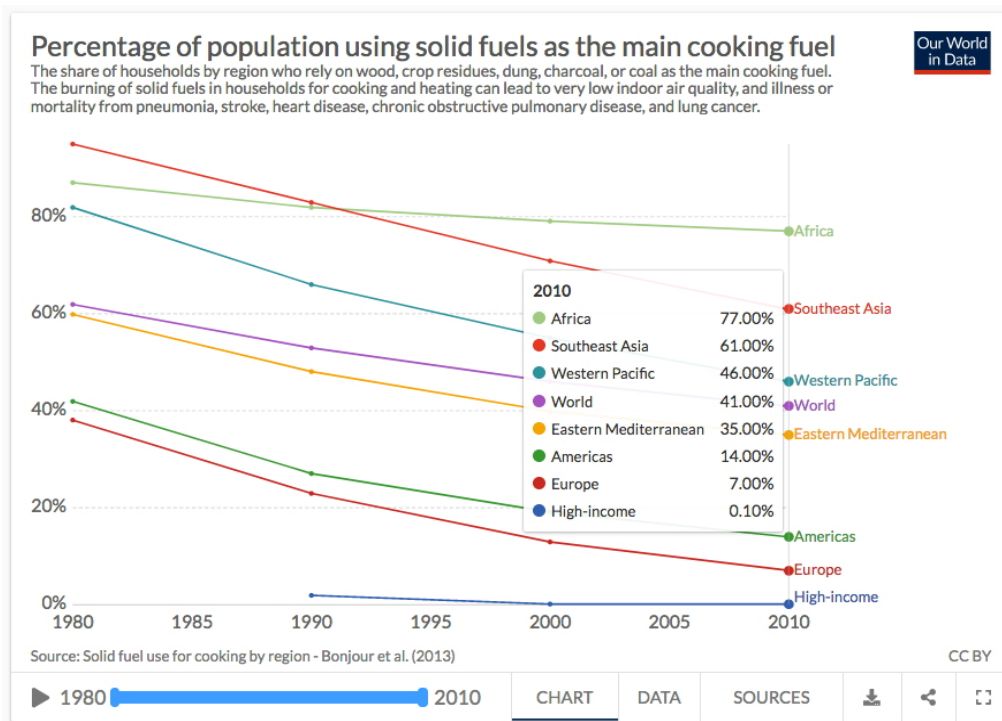
This means GLOBALLY there's an URGENT need for governments to explicitly support industrial partnerships between the Nuclear & the WWS energy sectors. Especially rich and developed countries, who have historically dominated fossil energy resources – usually by force – leading to their huge infrastructure, industrial and wealth advantages, must now re-dress these imbalances by aiming to: a) domestically create tens of thousands of new jobs building infrastructure; b) globally expand their technology exports c) freely share energy generation IP (Intellectual Property) rights; and d) ensure the private sector engages in immediate and ongoing action to realise and sustain these outcomes.



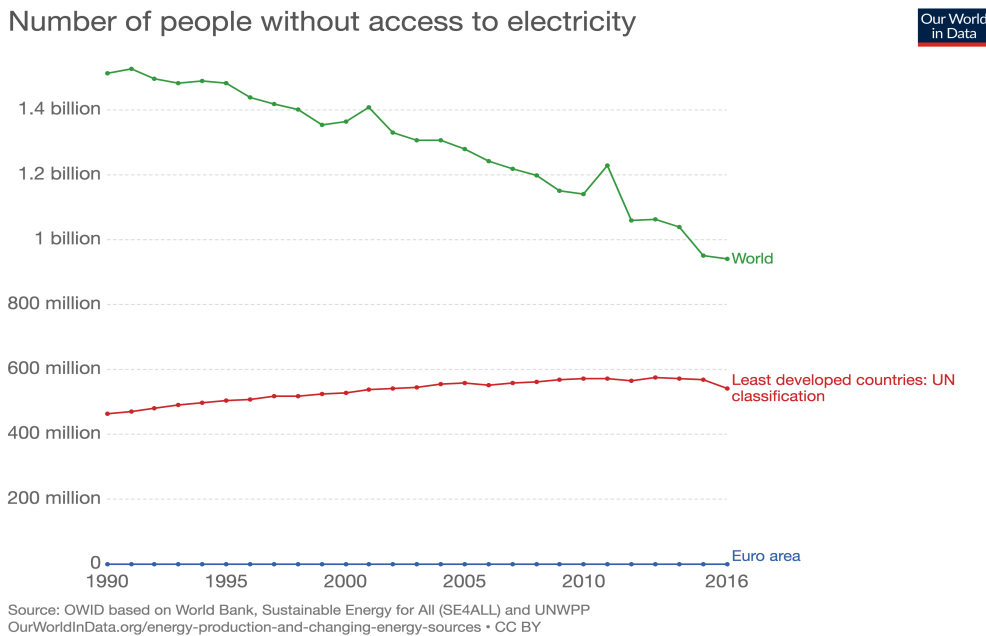
One of the defining inequalities in the world today is that between the electricity rich and the electricity poor. Electricity is the world's most important and fastest-growing form of energy. However, global electricity generation still accounts for between only **9%** to **15%** (depending on data source) of global energy consumption. [3](#) [4](#) Poverty, women's rights, climate change — indeed, most of the world's most pressing challenges — can be explained by answering one question: can you turn on your lights, if you're lucky enough to have them? While electricity availability doesn't guarantee wealth, its absence almost always means poverty. Darkness kills human potential. Electricity nourishes it. [5](#)

In the battle to replace Big Fossil, there are many compelling equality benefits that an 'Ultimate Power Couple' partnership between the Nuclear and Wind, Water & Solar (WWS) electricity generation sectors could yield, for example:-

1. Eliminate millions of unnecessary deaths, disease and dramatically shortened life spans from respiratory and related diseases, and injuries caused by a) breathing emissions from burning fossil fuels (coal, oil and gas) which have an **85%** share of global energy demand, and b) breathing smoke from bio-fuels' **8%** share, used to cook and keep warm by burning wood, dung and grass; [6](#)



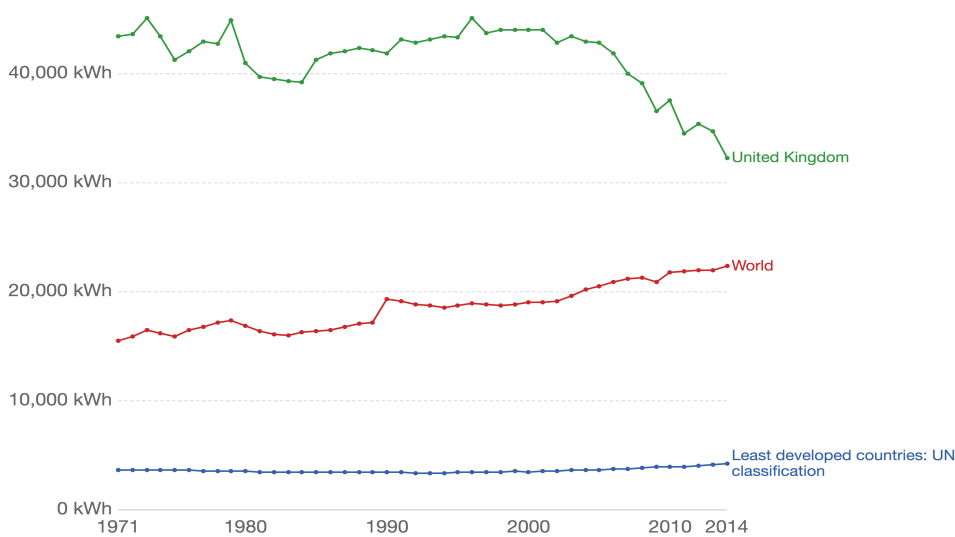
2. Connect electricity to **12%** of humans - nearly a billion people - now off grid. More than half the 1 billion people in the Least Developed Countries (LDCs) [7](#) live on less than a dollar a day. Women in LDCs have a one in 16 chance of dying in childbirth, compared to one in 3,500 in Europe; LDCs are among the groups of countries most affected by climate change, while they contribute least to it. Many LDCs are also small islands whose very survival is threatened by rising sea levels; [8](#)



3. Increase electricity supply to 3 billion people on the planet today who are using less energy than the equivalent electricity needed to run by an average refrigerator.

## Energy use per capita

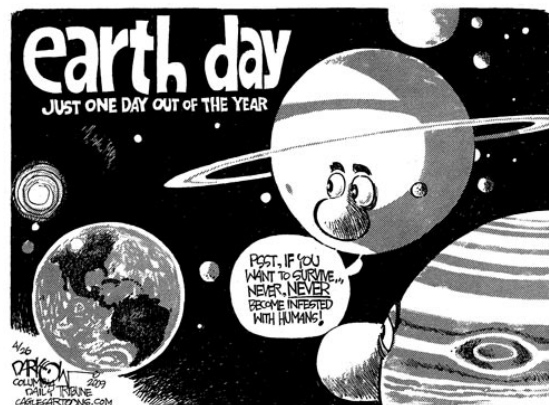
Annual average per capita energy consumption is measured in kilowatt-hours per person per year.



Source: International Energy Agency (IEA) via The World Bank OurWorldInData.org/energy-production-and-changing-energy-sources/ - CC BY

Few would argue with these aims, but they cannot be realised by the Wind, Water & Solar power sectors alone, which will struggle to grow from their current supply of circa 2% of global energy demand, because they:-

1. Can't produce enough net electricity to cover the energy embedded in their own construction; causing
2. Orders of magnitude increases in mining & industrial-scale "extractivism" [9](#) activities "renewable energy does nothing to remake exploitative relationships with the earth" compared to Nuclear power; causing
3. Huge increases in fossil fuel burning to power material processing and infrastructure build-out, eroding health, wellbeing and life spans; causing
4. Mass industrialisation of nature accelerating the already rapidly degrading and impoverished local communities [10](#) and the natural environments people rely on rather than embracing gargantuan projects; plus
5. Countless unborn generations will be denied access to essential non-fuel fossils resources if early 21st Century humans are foolish enough to chase the 100% renewables unicorn, by greedily burning all remaining finite and irreplaceable coal, gas and oil reserves, which we're already half way through. [11](#)



Externalities enjoyed in the developed world, such as the historical infrastructure advantages, all won largely on the back of Big Fossil's toxic persistent exponentially expanding (from 1940 to 1970) deadly emissions over the last few hundred years, must not be ignored or made invisible in our deliberations and actions. Do we deny much of the rest of the global population access to abundant energy because some of us now enjoying these infrastructure advantages have adopted a false "austerity" rhetoric? But in defence of what? When Nuclear power can provide for every human beings' needs more equally and reduce energy access inequality more efficiently by every metric we care to apply? Ignoring such day to day / historical advantage is, I argue, both anti-scientific and thus immoral so I reject it in favour of Nuclear power as quickly as possible for the many not the few. I call this just being fair.

Arguments over global warming don't reduce the weight of these conclusions. Even if you think climate change doesn't exist at all, the above aims and conclusions remain just as urgent and just as firm. Being "agnostic" about Anthropogenic Global Warming, or a "believer" in CO<sub>2</sub>, methane from cow farts, fluffy stratospheric clouds, or the "tooth fairy" can only add, but never subtract moral & scientific weight of the conclusion that:

**Humanity URGENTLY needs to Electrify 1 billion people now off-grid, Electrify Transport, Electrify domestic Heat & industrial process Heat and Maximise Energy Efficiencies in EVERYTHING æNOW!**

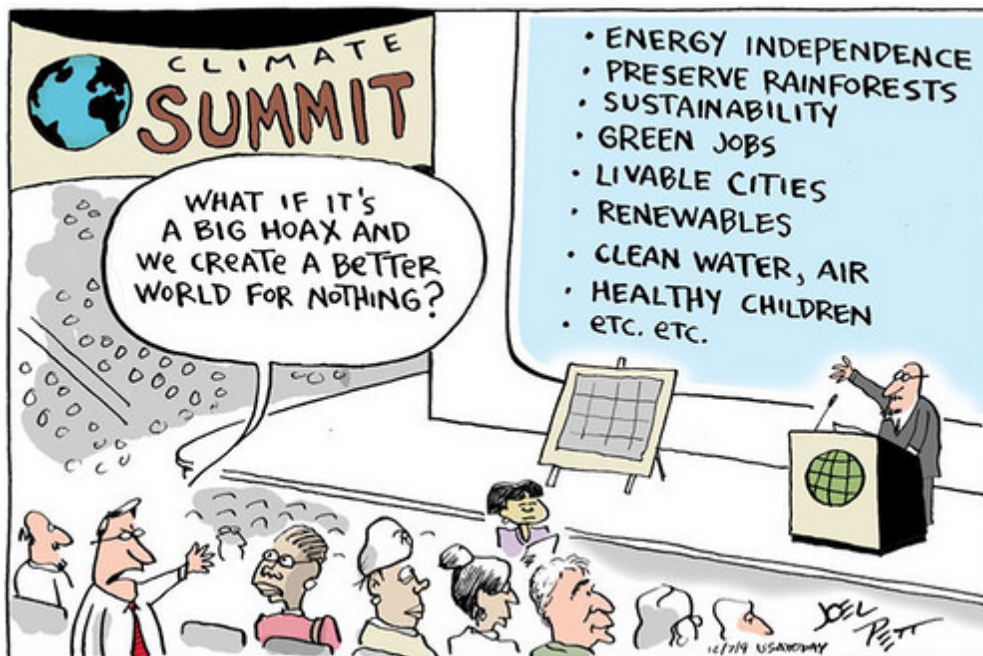
Natasha Thoday [12](#) [13](#)  
Brighton, September 2019



## 1. Environmental leaders switch to supporting Nuclear Electricity Generation

Many now acknowledge their previous opposition to Nuclear power was irrational. [14](#) People such as Greenpeace founder Patrick Moore, Friends of the Earth founder Bishop Hugh Montefiore, Whole Earth Catalog founder Stewart Brand, WWF Jared Diamond, and academics such as Tim Flanery, John Holdren, James Kunstler, Bill McKibben and James Lovelock, together with author Gwyneth Cravens, journalist Mark Lynas, historian Richard Rhodes and activist Michael Shellenberger one of the world's leading pro-nuclear environmentalists & atomic humanist movement founder, [15](#) have all decided that Nuclear power is consistent with environmental values. [16](#) [17](#) In contrast, people who switch to supporting Nuclear power seldom if ever switch back to not supporting it.

Climatologist Dr James Hansen said: "Can renewable energies provide all of society's energy needs in the foreseeable future? It is conceivable in a few places, such as New Zealand and Norway. But suggesting that renewables will let us phase rapidly off fossil fuels in the United States, China, India, or the world as a whole is almost the equivalent of believing in the Easter Bunny and Tooth Fairy."



## 2. The Data is Clear - Non-Nuclear 100% 'Wind Water Solar' (WWS) "simply won't work"

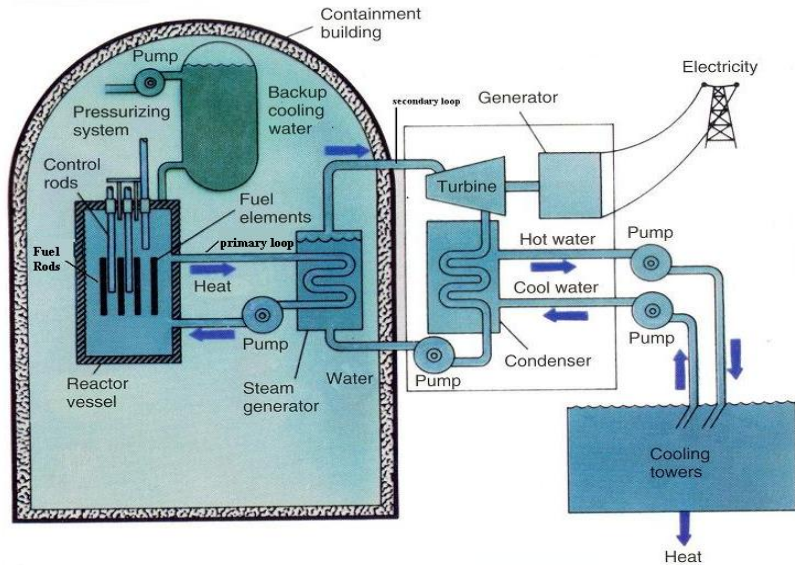
Global warming is very likely being caused by humans emitting greenhouse gases. [18](#) There is a high degree of confidence amongst climate scientists, and the general scientific community, that the dominant cause of observed global warming has been humans burning ever more Carbon Dioxide (CO<sub>2</sub>) emitting coal, gas, & oil over the last several hundred years. "There was 99% scientific consensus in 2011 that humans are causing global warming." [19](#)

The world's climate is a chaotic system. Even after decades of intense study and billions in research funding, scientists have barely begun to comprehend all its workings. Even if global climate change factors other than CO<sub>2</sub> turn out (following new analysis and evidence being robust enough to withstand the cut and thrust of scientific peer review to change today's consensus) to be equally or more significant [20](#) then we should preserve fossil coal, gas & oil reserves for future generations in any case, not selfishly burn them all now: about **13%** of total petroleum products consumed in 2017 were for non-combustion but vital non-fuel uses.

Big Fossil now accounts for more than **85%** of global energy consumption and rising (in 2018 by **2.3%** - its fastest pace in ten years - with only **30%** of that increase due to renewables and nuclear). [21](#) Only about **2%** of global energy consumption is accounted for by Wind & Solar, with **2%** by Nuclear power and **3%** hydroelectric. Apart from traditional bio-mass **8%**, per unit of energy generated, burning fossil coal, oil and gas kills and disables tens of thousands times more than all other energy sources combined, with Nuclear power having the lowest mortality and injury rate of all, close to zero (details below).

For this reason alone, the immediate and rapid expansion of Nuclear powered electrification is essential to building an ethically just global energy system.

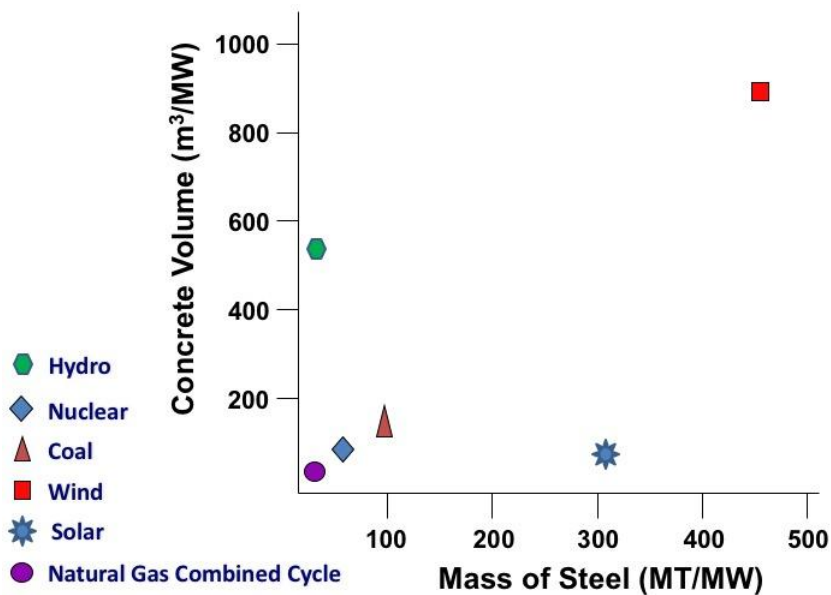
Schematic of a Nuclear Power Plant



Meanwhile humanity faces largely unavoidable –Deep Adaptation“ [22](#) to global warming induced social & environmental chaos.

To address this emergency, multiple decarbonisation studies show that financial, social, and environmental costs spiral out of control as Wind Water Solar (WWS) penetrates into (models projecting the future make-up of) electricity grids above circa **75%** and that Nuclear Power generated electricity is the 'least-worst' choice for humans to make-up the remaining **25%** in balanced modern low-carbon grids. [23](#) [24](#) [25](#) [26](#) [27](#) [28](#) [29](#) [30](#) Remember: global electricity generation accounts for only **9%** to **15%** of global energy consumption.

The cost escalation seen in studies of non-Nuclear 'scenarios' (models with aggressive carbon constraints) is mostly due to low energy density WWS renewable electricity generation's extra build-out demands – like the huge numbers of plants themselves, and their distribution & storage infrastructure, cumulatively far exceeding global supplies of the construction materials & minerals needed, with their embedded extraction, mining & refining fossil fuel energy – which becomes necessary in future 'scenarios' that rely exclusively on variable renewable electricity generating technologies. [31](#)



### Materials needed to install various energy systems

Wind Water & Solar renewables require many times the amount of steel and concrete to build generating plants than thermal sources, such as Nuclear, coal & gas. [32](#) Solar and Wind farms require between 400 and 750 times more land than nuclear and natural gas plants. [33](#)

But even if raw materials and their embedded fossil fuel extraction energy were not a limit, electricity grid instability problems arise, such as increasing risks of power-cuts with too little fossil or Nuclear base-load and dispatchable capacity. [34](#)

The underlying problem is that WWS electricity generating technologies are too unreliable and energy-dilute on their own. Modern civilization has evolved as a direct expression of (high energy density) fossil fuels. The

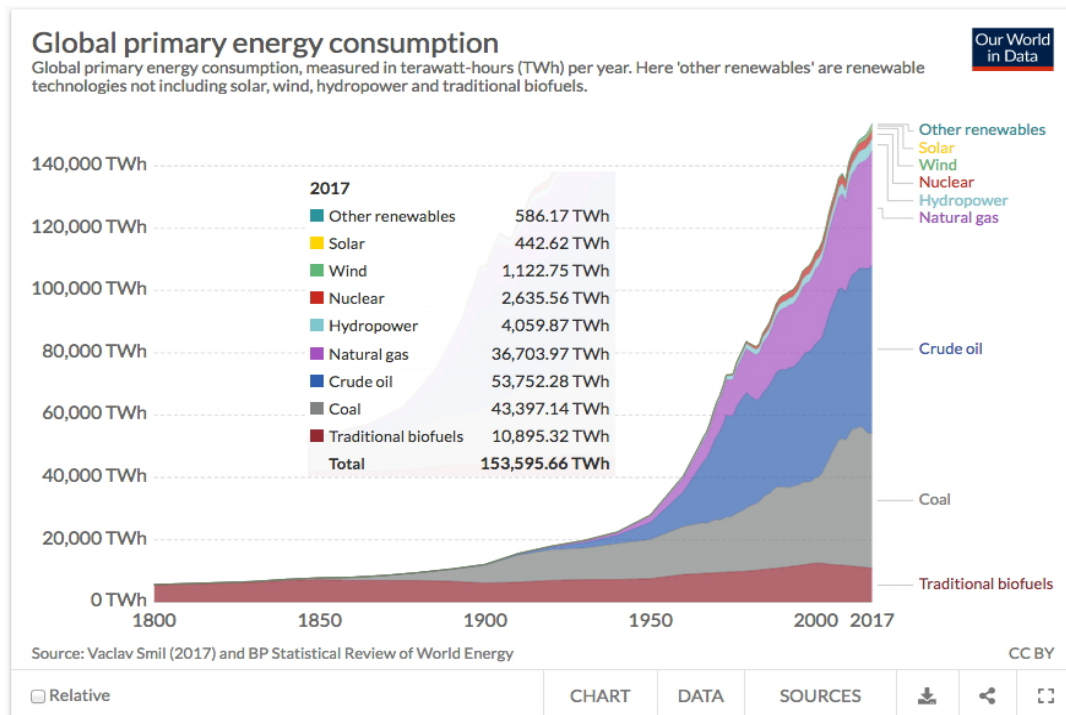
inevitable (and desirable) move to new energy arrangements involving an increase in renewable (low energy density) sources will require society to undergo profound spatial restructuring of our energy systems. [35](#)

Below we explore the impacts this will demand, and why and how the Nuclear and WWS sectors must abandon historical antagonisms and work together in partnership to urgently decarbonise human energy use.

### 3. Accurate Trustworthy Data

#### A) Total global primary Energy & Electricity consumption by Sector

In 2017 Wind, Solar & Geothermal accounted for under **2%** ; Hydropower roughly **3%**; Traditional bio-mass about **7%**; Nuclear circa **2%**. All the rest was Big Fossil **85%** [36](#) according to senior academics and scientists at the University of Oxford based Global Change Data Lab (GDCL). [37](#)



According to BP 2018 Statistical Review of World Energy data, Wind, Water and Solar together accounted for only **9.4%** of total energy consumption in 2017. [38](#)

Total Global electricity consumption (in 2014) accounted for only about **14%** of primary energy consumption, [39](#) [40](#) with Nuclear electricity consumption accounting for only **11%** (down from a high of **18%** in 1996).

GDCL also report UK electricity consumption (in 2015) accounts for circa **16%** of overall primary energy used. [41](#) [42](#) Since 2000, UK energy usage has decreased by **20-25%**, but globally from 1970 to 2014, average consumption increased by approximately **45%**, whilst **12%** of the world's 7.7 billion population are still without electricity.

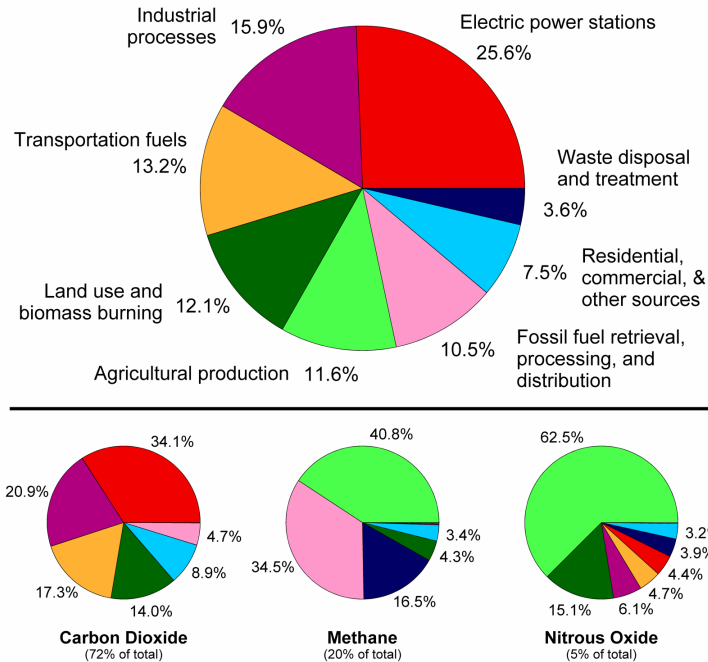
Non-Nuclear lobbyists, such as **REN21** (a global 100% WWS industrial members networking association aiming to shape the energy debate) [43](#) agree closely with GDCL data, reporting global primary energy consumption in 2016 thus: Wind, Solar, Geothermal, & Ocean power **1.7%**; Biomass & Biofuels **5%**; and Hydropower **3.7%**. Traditional bio-mass **7.8%**; Nuclear **2.2%**; and Big Fossil accounting for **79.5%**. [44](#)

#### B) Green House Gas Emissions by Sector

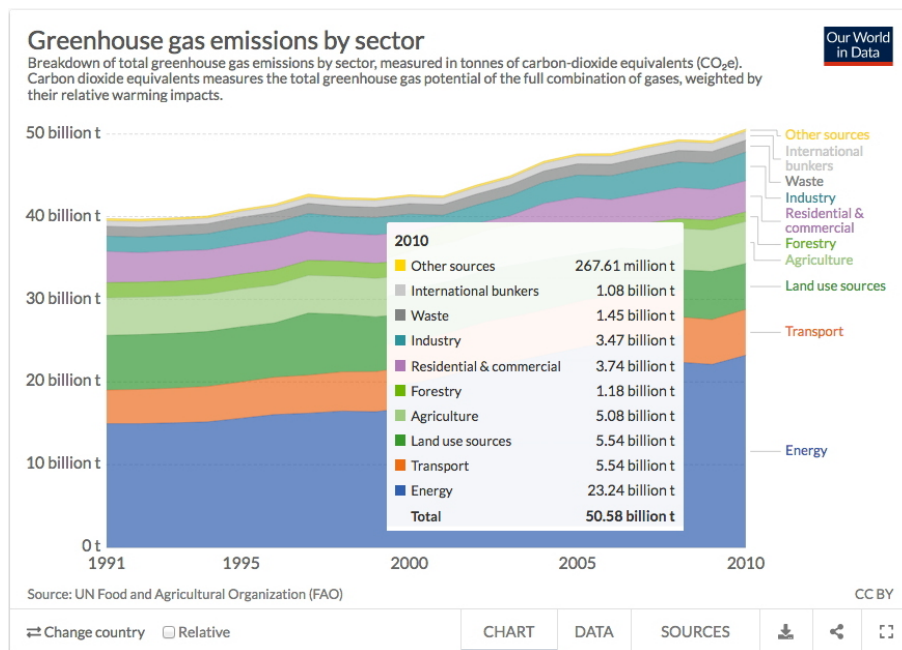
Carbon emissions climbed by **2%** in 2018, faster than any year since 2011 caused by the demand for energy easily outstripping the rapid rollout of renewable energy, [45](#) of which only **9%** to **15%** of global energy consumption is consumed as electricity (see above).

The figure below shows the relative fraction of man-made greenhouse gases coming from each of eight categories of sources, as estimated by the Emission Database for Global Atmospheric Research version 4.2, Fast Track 2010 Project. [46](#) These values are intended to provide a snapshot of global annual greenhouse gas emissions in the year 2000. The top panel shows the sum over all anthropogenic greenhouse gases, weighted by their global warming potential over the next 100 years. This consists of 72% carbon dioxide, 20% methane, 5% nitrous oxide and 3% all other gases. Lower panels show the comparable information for each of these three primary greenhouse gases, with the same colouring of sectors as used in the top chart. [47](#) United States Environmental Protection Agency gives similar results. [48](#)

## Annual Greenhouse Gas Emissions by Sector



The chart below shows total greenhouse gas emissions in 2014 (measured in their carbon-dioxide equivalent values i.e. including nitrous oxide and methane) based on Intergovernmental Panel on Climate Change (IPCC) data. [49](#) Agriculture **10%**, forestry **2%**, and land use **10%** (AFOLU) are responsible for about one-quarter of global greenhouse gas emissions, and yield a similar result to that of the Fast Track 2010 Project data (above). [50](#)



Germany's experiment closing its Nuclear electricity plants has not reduced its carbon emissions, which are set to rise, as are other pollutants. [51](#) Compared to France it produces ten times the emissions at twice the end user price per unit of energy because France receives 75% of its electricity from nuclear. Same in California. Strong evidence its nearly impossible to replace fossil without Nuclear. [52](#)

All decarbonisation 'plans' – whatever % Nuclear or 100% WWS electricity generation – will require a rapid and massive expansion of electricity storage and distribution technologies to have any chance of decarbonizing big fossil's **85%** and rising domination of the yet to be electrified energy sector.

### 4. Intermittency & Storage: one of the Achilles heel of Wind Water & Solar (WWS) power generation

Grid-scale energy efficient power storage is required for WWS to work as a mature non-parasitic electricity generating technology. [53](#) [54](#) When there's no sun or wind, intermittent WWS renewables (low energy density) must be backed-up by on-demand dispatchable electricity generation or storage (high energy density). [55](#)

Hydro provided **2.64%** of global energy [56](#) with pumped storage generating **16.4%** of the world's electricity in 2016, but it has very limited potential to expand [57](#) and has the highest death rate of all renewables (1,400 deaths/million GWhr). [58](#) Geography and politics prevents further expansion in the UK beyond circa **2%** of its electricity generating capacity. [59](#)

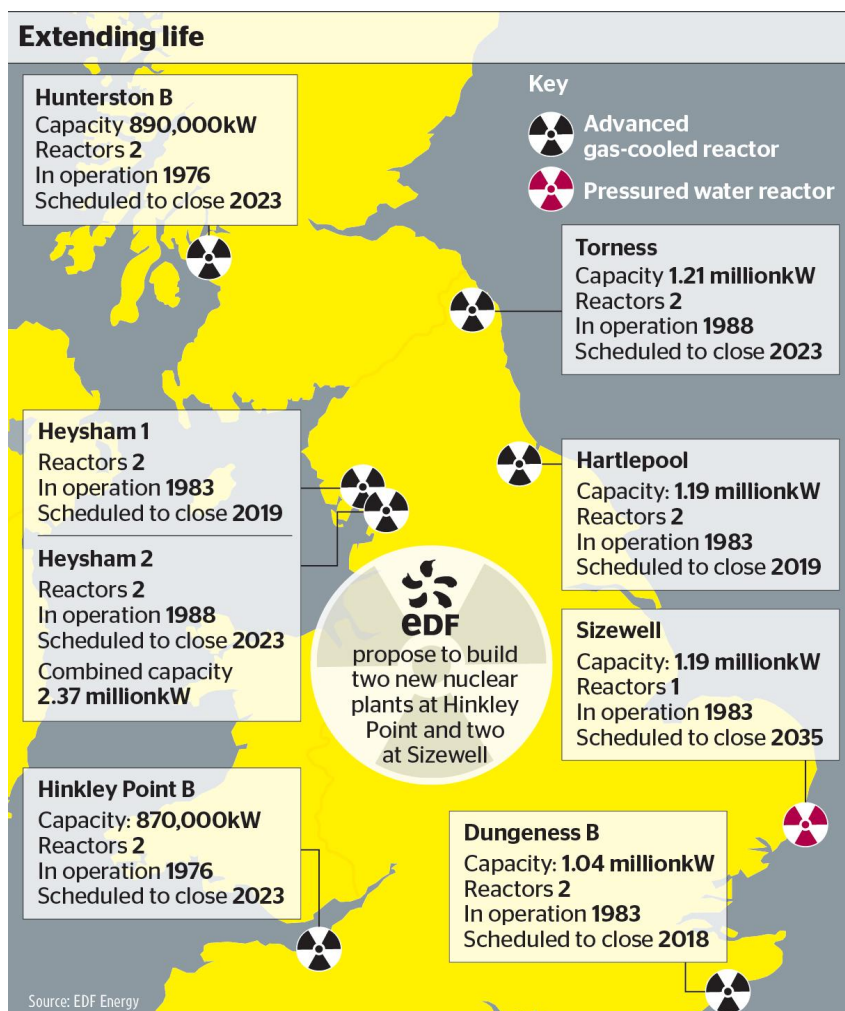


Battery storage will always be far too expensive environmentally and financially. [60](#) [61](#) No digital-like 'Moore's law' 10x gains exist for batteries to take over any time soon. If batteries scaled like digital tech, a battery the size of a book, costing tuppence, could power a jetliner to Australia. But that only happens in comic books. [62](#) The maximum theoretical energy in a kilogram of the best battery chemicals is 15x less than that in a kilogram of oil. And it takes the energy-equivalent of 100 barrels of oil to fabricate enough batteries to store the energy-equivalent of a single barrel of oil. [63](#)

Geothermal energy capacity is insignificant in the UK [64](#) and globally only 83GW. [65](#)

### 5. No choice : Nuclear Power Must be in the mix for 'plans that add-up' in short, medium, & long terms

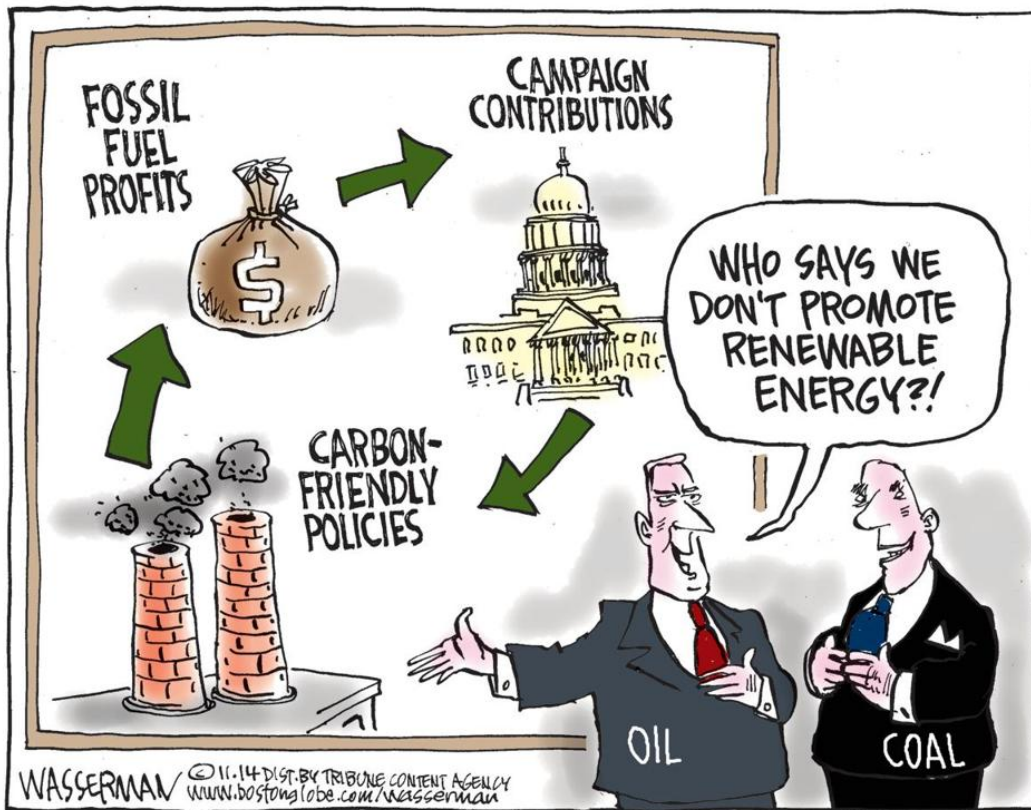
The UK has 15 Nuclear reactors generating about 21% of its electricity in 2019 but almost half of this capacity is to be retired by 2025. [66](#) In the short term, to avoid power cuts with this reduced base-load Nuclear, the only choices available to UK grid engineers, when there's no sun or wind – to replace this lost Nuclear capacity – is going to be some combination of on-demand dispatchable fossil gas, coal & oil.



The global fleet of Generation 3 water and gas cooled Nuclear reactor power plants are not perfect, but renewables could not even exist now – nor can they scale up much in the future – without increases in embedded high energy density fossil fuels.

In 1966 the California Sierra Club's Board of Directors (the prototype global environmental pressure group) voted nine-to-one to support the building of the Diablo Canyon nuclear plant to replace fossil fuels. "Nuclear power is one of the chief long-term hopes for conservation" argued Sierra Club President Will Siri.

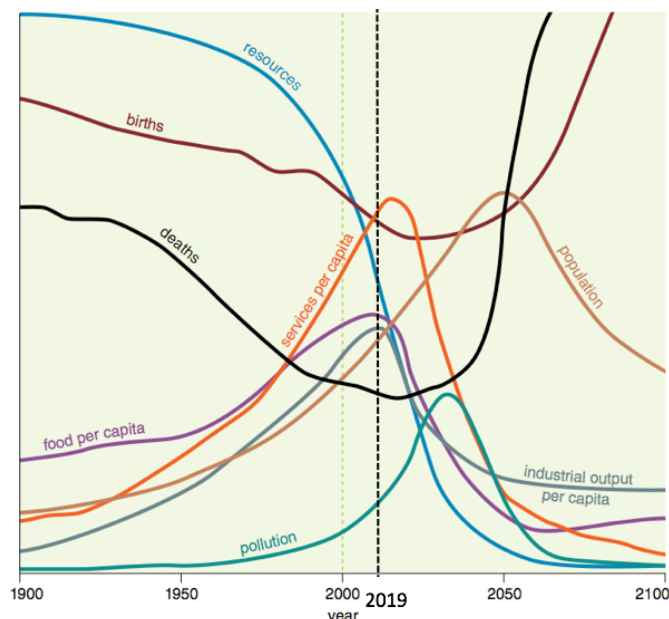
In response, the sole dissenter, David Brower quit and started a new group, Friends of the Earth (FOE). "There's no more important issue in my life," said Brower, than to "see that Friends of the Earth does everything it can, here and abroad, to stop the nuclear experiment." The founding donor of FOE was oilman Robert Anderson, owner of Atlantic Richfield. He gave FOE the equivalent of \$500,000 in 2019 dollars. "What was David Brower doing accepting money from an oilman?" his biographer wondered. The answer is that he was developing the environmental movement's strategy of promoting renewables as a way to greenwash the killing of nuclear plants and the expanded use of fossil fuels. Big fossil has been exploiting and directly financing and organising anti-nuclear propaganda using environmental groups like FOE and Greenpeace as smoke screens ever since. [67](#)



This means that in the short to medium term, non-Nuclear 100% WWS 'plans' to displace Big Fossil's grip on the world's electricity grids, and indeed expand those grids, must accept that however well intentioned, their decarbonisation goals will stall and reverse, due to both the physical and the propaganda / funding reasons discussed above, whilst waiting for long anticipated but yet-to-emerge technologies such as: Smart-Grids (online micro load management hardware, to match local demand-intermittency in every building, with continent-wide grid generation-intermittency); [68](#) [69](#) Ocean Thermal Energy Conversion; [70](#) Mass Thermal Storage (in every building); Mass Carbon Capture (to enable fossil & bio-fuel carbon neutrality); [71](#) [72](#) [73](#) Power to Methane; [74](#) Synthfuel; [75](#) Graphene Super Capacitors; [76](#) [77](#) Nuclear Fusion (lack of funding means its always 30 years away); and the mythical Hydrogen / Fuel Cell economy (ditto). [78](#) [79](#) [80](#)

In particular, to become large scale industrial process in the real world, energy storage technologies such as Power to Methane, Synthfuel, and Hydrogen, all depend (if we don't care about CO2 emissions) on either fossil fuels, or if we are serious about reducing Anthropic Global Warming, then massive expansions of existing (high energy density) Nuclear power technology, as these chemical synthesis processes require lots of (high energy density) heat [81](#) which (low energy density) WWS power is poorly suited to supply. [82](#) [83](#) [84](#)

The figure below based on the 1972 book 'Limits to Growth' shows that even without Nuclear power and abundant fossil fuels humanity is already facing collapse. [85](#) The 2019 line is drawn based on where the world economy seems to be now, rather than on precisely where the base model would put the year 2019. "There have been many amazing coincidences over the past 4 billion years that have allowed life to continue to evolve on this planet. More of these coincidences may be ahead. We also know that humans lived through past ice ages. They likely can live through other kinds of adversity, including worldwide economic collapse." [86](#)



At the urgent pace now required to decarbonise, the only technically and politically possible way is for WWS electricity generation to work in partnership with tried and tested Nuclear Powered electricity generation. [87](#) Only by working together can Nuclear and WWS retire fossil fuels from the energy business, so that humanity can earn itself a break from impending climate chaos, being caused by well known Limits to Growth with the required response of Deep Adaptation and instead concentrate on ushering in all these wonderfully promising, but yet-to-emerge technologies.

As we shall explore more fully below, increasing Nuclear power build-out (high energy density) would also significantly offset Wind Water & Solar power's (low energy density) impossible to achieve land, mineral, environmental, and embedded extraction and construction fossil fuel energy demands.

The message is clear: we – i.e. the Wind Water Solar & Nuclear industrial sectors on behalf of humanity – need to urgently decarbonize over three quarters – **85%** and rising – of global energy use by a combination of Electrifying the **12%** of humanity now off grid, Electrifying Transport, Electrifying Heat (domestic & industrial process) and Maximising Efficiencies in EVERYTHING.

## Part TWO: Science Informs Politics

### 6. Scientists support Nuclear energy to help achieve IPCC under 2-degree Decarbonisation Targets

Surveys show with a high degree of confidence that the general scientific community, including most prominent climate scientists who've expressed a public opinion, believes both:-

1. Global warming's dominant cause is human greenhouse gas emissions (mostly carbon dioxide) meaning we face “deep adaptation” [88](#) [89](#) to climate induced global chaos; and
2. Nuclear power must be part of human response because it:-
  - a) Generates the least greenhouse gas emissions; and
  - b) Has the least overall financial, environmental, and social costs of all; [90](#) and
  - c) Is the only present-day low-carbon technology with the demonstrated ability to scale-up to meet many, if not all, the energy demands of modern economies far into the future with an inexhaustible supply of uranium and other metals needed to build nuclear reactors dissolved in seawater (see below). [91](#) [92](#)

A 2015 PEW survey of the American Academy for the Advancement of Science [93](#) [94](#) found 87% of scientists believe global warming is being driven, at least in part, by human activity, with 65% saying they favour building more Nuclear power plants, or at the very least, feel that it should be on the table as an available emissions-mitigation option.

### 7. We need a shared Pro-Arithmetic Ethical Plan that 'Adds Up'

The late Sir David MacKay, polymath, author of the influential book 'Without Hot Air' and head-hunted UK government climate change advisor, appealed to his readers –Please don't get me wrong: I'm not trying to be pro-Nuclear. I'm just pro-arithmetic. The one ethical position I wish to push is –we should have a plan that adds up“.” [95](#) [96](#) [97](#)

Despite being well intentioned, well-financed and well-organised, unfortunately non-Nuclear 100% renewable WWS 'plans' do NOT 'add up', becoming 'An Exercise in Magical Thinking' [98](#) with objections to nuclear eventually boiling down to a handful of arguments that are well-meaning but often ignore basic facts. [99](#)

They start with a hidden in plain sight contradiction: on the one hand accepting and urgently wanting to act on the scientific consensus that anthropic global warming is real; but then disregarding the same scientific consensus that humanity needs Nuclear power's unique balance of advantages / disadvantages to meet global decarbonisation goals to avoid climate induced social chaos and breakdown.





Such inconsistency is obscured and sustained by inflating 'Nuclear radiation contamination' fears way beyond what the data supports. [100](#) This leads people to believe the pollution risks are too great even to consider Nuclear. But if its 'true' that 'radioactive Nuclear power 'waste' is dangerous for -millions'' of years' [101](#) [102](#) (its not) then creating more can not make the 'problem' worse: we're 'stuck with it' anyway (we're not) and since humans already barely have enough time or resources to prevent -an inevitable near term social collapse due to climate change'' [103](#) we may as well decarbonise as quickly as possible with Nuclear's help.

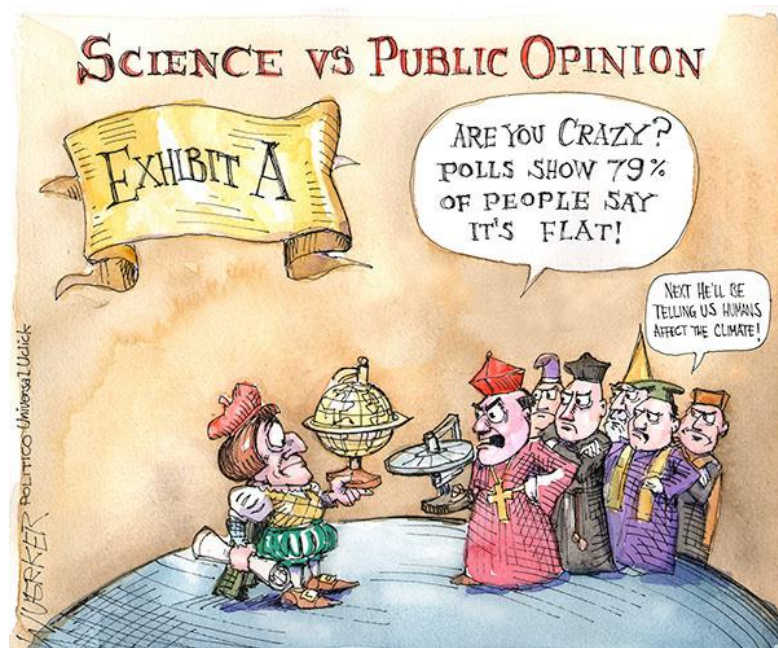
These issues and objections are explored further below, in particular the Nuclear 'waste' problem which has now been solved by 'burning' it in new reactors i.e. recovering all its otherwise wasted energy rendering it 'safe as background in 300 years'.

#### 8. There are no short-cuts around Political Engagement

Risk perception is an intrinsic, biologically rooted, inescapable part of how the human animal behaves. We need to accept this and use what we know about the way humans respond to risk in order to help ourselves make better, healthier choices. We need to bring the risk perception factors out of the subconscious shadows and use them as practical tools to allow our rational thinking to have more influence in the policy making process. [104](#)

When people express their hatred of Nuclear, stoked up by media -if it scares, it airs'' stories, they usually argue about: the dangers from radiation leaks; the risk of weapons proliferation; the Nuclear waste problem; and that Nuclear power is too expensive; and in any case - we just don't need it! - but none of these objections have solid scientific or political backing (as we shall explore more below). If they did, countries around the world (like USA, UK, France, Finland, Russia, China, India, South Korea, UAE) would not continue to build new Nuclear power plants to supply their growing need for energy.

Policy decisions based on fears rather than facts can lead to decisions that feel good (e.g. no Nuclear) but increase the overall risk to the population (more deaths and health risks from burning fossil fuels and climate risks from greenhouse gas emissions). [105](#)





In contrast China has a 'go global' policy of exporting Nuclear technology. [106](#) But China has seen a four fold increase in energy consumption per capita since the 1980s and is now the largest importer of oil, coal, and natural gas in the world, which it uses to manufacture exported goods to countries that are decreasing energy consumption per capita.

Bright Green Environmentalists differ from the mainstream 'Back-to-Nature' romantic ideal of modern environmentalism, arguing that humans should protect nature by actively perusing technology to "decouple" anthropogenic impacts from the natural world. [107](#) Eco-Modernists [108](#) "affirm one long-standing environmental ideal, that humanity must shrink its impacts on the environment to make more room for nature ... Urbanization, agricultural intensification, Nuclear power, aquaculture, and desalination are all processes with a demonstrated potential to reduce human demands on the environment, allowing more room for non-human species. Suburbanization, low-yield farming, and many forms of renewable energy production, in contrast, generally require more land and resources and leave less room for nature." [109](#)

Below we explore the "numerous shortcomings" in 'plans' put forward by 'non-Nuclear 100% WWS' renewable energy lobbyists in particular how they quietly enable their 'scenarios' to gobble up vast tracts of land, mineral resources, and fossil fuels.

## **Part THREE: 100% Wind Water & Solar power is –nonsensical“ in spite of –capturing the public imagination“**

### **9. Wind Water and Solar power can't produce enough energy to cover its own embedded construction energy**

Water, Wind & Solar installations represent a net energy loss and cannot power their own paradigm shift alone. In 2011 Google says it invested over \$850 million in the renewable energy sector, so are highly motivated to reduce their huge energy bills. [110](#) They concluded in 2014 after 4 years of effort that renewable energy –simply won't work“ according to the scientists who led the research programme. [111](#) [112](#) The key problem appears to be that the cost of manufacturing the components of the renewable power facilities is far too close to the total recoverable energy – the facilities never, or just barely, produce enough energy to 'balance the budget' of what was consumed in their construction.

A 'balanced budget' of WWS plant also includes fossil fuels to manufacture all the parts, and mine and refine raw materials like iron, copper, lithium, cobalt, (more below) and, however abundant, rare earth metal ores, which are not really replaceable, [113](#) even with modern Reluctance generators that don't need magnets [114](#) in wind turbines. [115](#) All must be transported by diesel throughout the production chain. Have you ever seen an electric cargo ship [116](#) [117](#) [118](#) [119](#) or JCB earth mover? Plus 5-25 years lifetime repeat costs of wind turbine [120](#) and solar power equipment components, and energy for continuous maintenance like cleaning of solar panels. And recycling issues. [121](#)



This leads to a runaway cycle of constructing more and more WWS renewable power plants, and supporting manufacturing infrastructure, micro-power distribution networks, all with inter-connecting continent-wide smart-grids, [122](#) simply to produce and deliver the energy required to manufacture and maintain WWS renewable energy facilities, an obvious practical absurdity.

### **10. It's not about Wind Water and Solar ~vs~ Fossil ~vs~ Nuclear it's about which mix makes sense**

When all the complexities are properly considered, it's clear that no single power generating technology is the best tool for the entire decarbonising job. All factors must be taken into account, such as geography, climate, weather, population density, whole life greenhouse gas emissions, infrastructure, air pollution, land and water impacts, and the evolving face of electricity end-use. Only a diverse and balanced energy mix can succeed, one which works in harmony with the needs of people, the realities of various different environments, and the engineering constraints imposed by physics and maths.

Running entirely counter to this principle, lobbyists pushing visions of 'non-Nuclear 100% WWS' disregard the global need for diversity in the energy system. This makes the task of balancing cost, energy security, and environmental considerations all the more difficult. Such 'voices' seem to dominate energy policy discussion and media attention, but regrettably they make no practical attempt to address all competing factors.

The IPCC partially resists these 'voices' but “Nuclear stigma“ is still very active active, for example in the way its unequivocal conclusion that nuclear is needed to meet the 2 degree goals (see page 304) is tucked away in the report's appendix and thus hardly known by any of the environmentalists who otherwise rely on IPCC for climate science. [123](#)

And in its 2018 Special Report SR15 [124](#) Nuclear generation increases on average 2.5 times by 2050 in the 89 mitigation scenarios considered; [125](#) and “limiting warming to 1.5°C is possible within the laws of chemistry and physics but doing so would require unprecedented changes.“; [126](#) but then yields biases in favour of these 'voices' such as promoting “policy interventions“ to “enhance affordability“ for renewables, but never suggest similar “policy interventions“ for Nuclear. [127](#)

For example, UK wind farms receive 40 per cent more cash when there's no wind or 'switched off' (i.e. curtailment, underlining the urgent need for a massive increase in storage capacity) [128](#) than supplying the grid, £108 million in 2017. [129](#) Nuclear Industry Subsidies are analysed here. [130](#) As we shall explore more below, such arguments miss that energy infrastructure is a 'Natural Monopoly'.

### **11. Failed Lawsuits : Dozens of Climate & Power-Grid experts judge Non-Nuclear 100% Wind Water and Solar power study “riddled with errors”**

Stanford University professor Mark Z. Jacobson [131](#) is one of the most infamous of the lobbyists 'voices', who's “outspokenness and solo style ... captured the public imagination“ [132](#) following a series (2009 - 2018) [133](#) of controversial studies. In 2011 Jacobson began vigorously promoting non-Nuclear 'Roadmaps' for 139 countries worldwide via campaigning network 100.org [134](#) [135](#) and The Solutions Project. [136](#)

In 2017 Jacobson filed, then later withdrew a well publicised “unprecedented“ lawsuit, demanding \$10 million in damages [137](#) [138](#) against a group of eminent scientists (Clack et al.) for their study [139](#) [140](#) published in the peer-reviewed scientific journal Proceedings of the National Academy of Sciences (PNAS) showing that the 'Roadmaps' contained “nonsensical“ assumptions, with a “staggering scale of modelling errors, inappropriate methods, and implausible assumptions [...] seriously impeding the move to a cost effective decarbonized energy system.“ For example they “overstated by roughly a factor of ten the ability of the United States to increase its hydropower output“ and would require “more than 1,500 square meters of land for wind turbines for each American ... a territory nearly twice the size of California“ which “render it [Jacobson's 100.org 'Roadmaps' ] unreliable as a guide about the likely cost, technical reliability, or feasibility of a 100 percent wind, solar, and hydroelectric power system.“ [141](#)



The 'Roadmaps' rely on yet-to-emerge mass thermal storage, demand-response smart-grids, [142](#) and the mythical hydrogen economy, in 'plans' using ridiculously vast tracts of land in order for Jacobson to claim he'd demonstrated U.S. energy (and later globally via 100.org) could be provided exclusively by renewable energy, primarily Wind, Water, and Solar. [143](#) [144](#)

“A project of such epic proportions could be implemented only under the auspices of an authoritarian and totally “green“ world government backed up by an equally “green“ populace, and the chances that we will see either at any time in the foreseeable future are zero.“ [145](#)

### **12. Zero Carbon Britain 'scenario' for a Non-Nuclear 100% Wind Water and Solar & the UK Green New Deal**

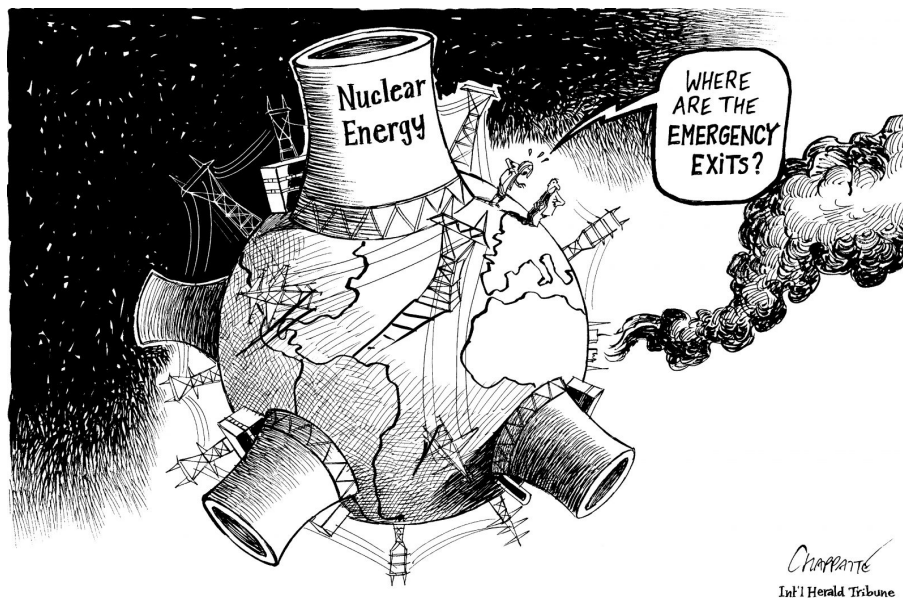
Another of these 'voices' is the 2013 Centre for Alternative Technology (CAT) [146](#) report Zero Carbon Britain (ZCB) [147](#) with the laudable aim of decarbonising the UK energy needs without Nuclear by 2050, but in so doing they show just how hard politically and physically challenging such a 'plan' would be. The UK's Green New Deal (GND) group's (most recent) 2015 report [148](#) has “drawn“ upon “much“ of the anti-Nuclear ZCB report. At the same time, GND acknowledge the Committee on Climate Change [149](#) pro-Nuclear stance as an “authoritative sustainable energy scenario“. The GND “was designed to kick start a rapid transition to a new

economy shaped to prevent a climate breakdown and transform a failed financial system. The GND will power a renewables revolution, [and] create thousands of green-collar jobs.”

[From the Committee on Climate Change report: “Alongside new renewables, technologies which can offer firm and flexible power, such as Nuclear and CCS, will be required for a power system in 2050 contributing fully to achieving overall net-zero emissions. The scale of deployment required by 2050 will necessitate continued investment in these options between now and 2050.”]

[From the Green New Deal 5th anniversary report: p18 “There are many authoritative sustainable energy scenarios for the UK that have been developed by a range of actors, including the Committee on Climate Change, research groups, business groups, and NGOs. The potential for the UK to go carbon free has most recently been extensively detailed by the Centre for Alternative Technology (CAT) in the report: 'Zero Carbon Britain: Rethinking the Future' from which much of the following is drawn.”]

Despite this hedging, some Green New Deal co-founder's have expressed a fear based irrational rhetoric against Nuclear power. One of them wrote a blog post in April 2019 to inform readers about what was presented as an "Historic Report" (by LUT University and Energy Watch [150](#) based on the “riddled with errors” 100.org / Jacobson study) the author commented that Nuclear is “[a]s profoundly wrong as burning our planet.” And that “pro-Nuclear power's rationality is not rational at all ceit's just another form of extinction risk. And we can well do without Nuclear œas Jeremy Leggett shows [in a .ppt presentation celebrating the LUT report]. So the answer is a simple one œelet's do without it, for good. No analysis will change that: playing with fire means we will get burnt. And Nuclear is worse than that.” [151](#)



Leggett, also a Green New Deal co-founder, set up Solar Century in 1998 with an annual turnover of £168 million in 2015-16, and is now pursuing £3 billion of projects in Latin America and Europe. [152](#) Its regrettable that Green New Deal group members refuse to acknowledge the overwhelming scientific evidence suggesting the long term commercial and political success of the Wind, Water and Solar electricity generation industries relies, indeed is guaranteed by having Nuclear in the mix, as we shall explore below.

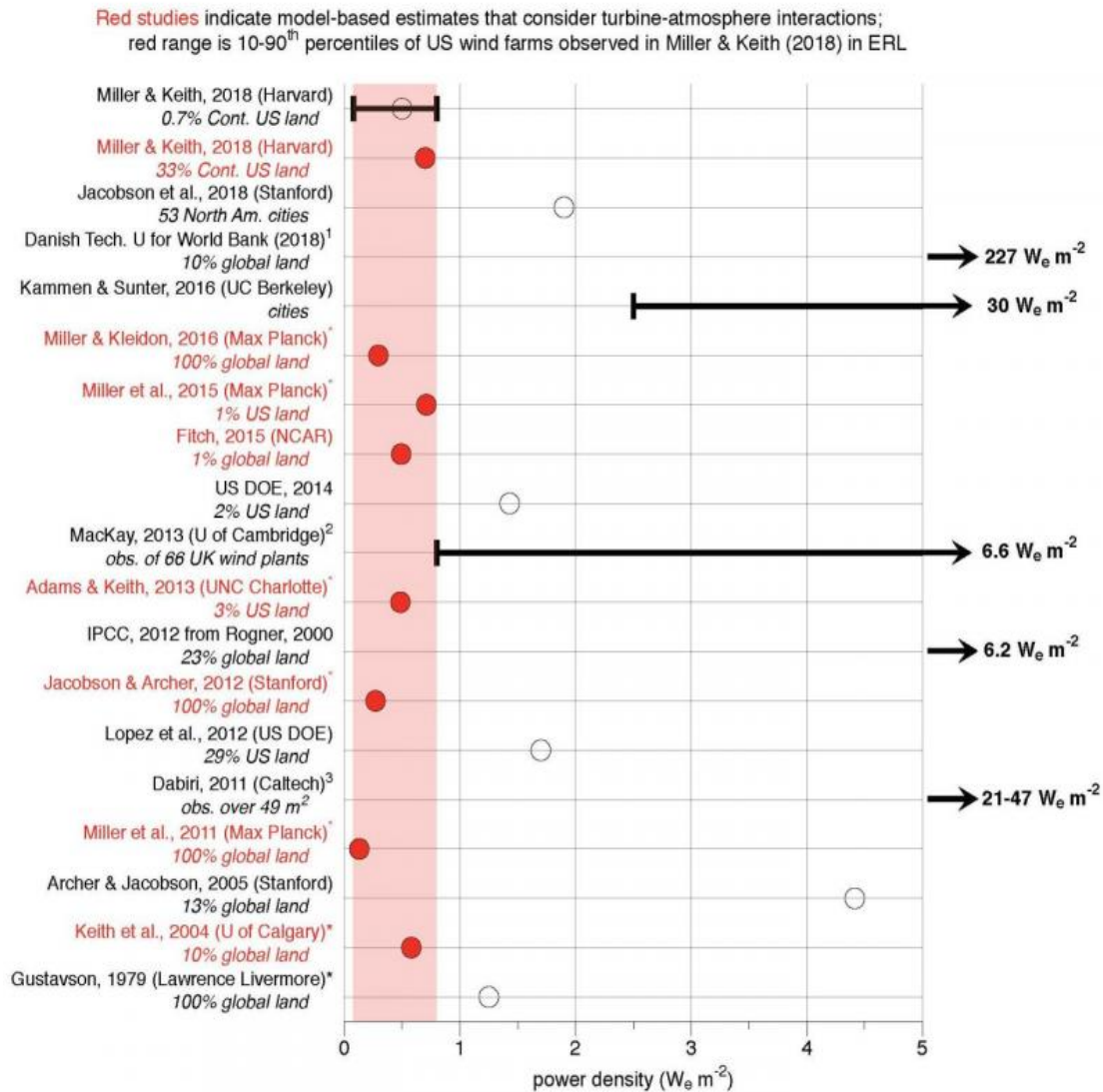
To begin with, the ZCB 'Scenario' and hence “much” of the Green New Deal 'plan' for the UK repeats many of the same 'Roadmap' “errors” as Jacobson / 100.org in trying to tackle the non-Nuclear 100% WWS Intermittency & Storage 'Achilles Heel'. To lower the **electricity** storage capacity needed by 2050, ZCB first suggests a **55%** reduction in UK power demand to 1,160 TWh per year by 2050 (Down from 2,535 TWh per year in 2010) with the aid of yet-to-be developed corporate “dream” smart-grids. [153](#)

### 13. Wind Water and Solar all need vast areas of Land & Sea to Build and Grow Infrastructure

To provide this more than halved **electricity** demand, the ZCB 'Scenario' builds offshore wind farms around the entire UK coastline providing **45%** (530 TWh/y) of capacity. But Wind (and Solar) power requires five to 20 times more land & sea area than previously thought according to Harvard University research published in 2018 and would significantly warm average surface temperatures. [154](#) These observation-based wind power densities are also much lower than important estimates from the U.S. Department of Energy (DOE) and the Intergovernmental Panel on Climate Change (IPCC). [155](#) [156](#)



First large-scale direct observation of wind energy's power density is consistent with physically-based models and inconsistent with wind resource estimates that ignore interactions between wind turbines and the atmosphere



[\*] for studies that compute power density limits (saturation), we report half the limit  
 [1] "The mean power density is a measure of the wind resource," (<https://globalwindatlas.info>); used in McKinsey & Co. Exhibit 8 in *Decarbonization of industrial sectors: the next frontier*  
 [2] relatively small wind power plants (range: 0.14-13.3km<sup>2</sup>, avg=2.4 km<sup>2</sup>)  
 [3] "Averaged over the 48.6 m<sup>2</sup> footprint of the six-turbine VAWT [vertical axis wind turbine array]..."  
 "in vacant desert...[with] topography [that] is flat for approximately 1.5 km in all directions"  
 used in Kammen & Sunter (2016) for city-scale estimate; see our 2 eLetter responses at <https://tinyurl.com/EstTooHigh>

Biomass & biogas then provides **20%** (237 TWh/year) of the ZCB 'Scenario's' power supply capacity, with a **75%** reduction ("agricultural GHG emissions down from 63.4 MtCO<sub>2</sub>e [in 2010] to 17 MtCO<sub>2</sub>e per year" in 2050) in the amount of grassland required for grazing livestock" by 2050 via a combination of [human] dietary changes" just to make way for yet-to-be bioengineered monoculture biofuels. ZCB research shows that we can [...] meet our entire energy demand without imports" meaning the 'Scenario' expects the UK to eat **75%** less meat / dairy implying most people become vegetarian or vegan claiming a healthier and more balanced average diet for the UK." [157](#)

All this effort – when there's week long winter lulls in wind and sun – to finally supply the grid with electricity from burning dirty inefficient biomass and biofuels, emitting large amounts of air pollution, whilst waiting for yet-to-emerge mass carbon capture incinerators and / or yet-to-emerge power to methane and mass thermal storage technologies, [158](#) and competing with food and water supplies. [159](#)

And where to grow all these monoculture yet-to-emerge bioengineered biofuels when the UK's 250,000Km<sup>2</sup> is **57%** farm, **35%** natural, **3%** green urban, and **6%** built on? (BBC summary based on 2017 Corine data). [160](#)

ZCB admits in its own report that they have to perform these anti-Nuclear ideological contortions because the total amount of [hydro] energy that can be stored is small [and the] UK's largest pumped storage station, Dinorwig in North Wales, can only store around 10 Gwh [but] the UK consumes far more than 1,000 GWh of energy on a single cold winter day."

**14. Electric Vehicles : Increase in Minerals, Mining & Fossil Fuel**



The Zero Carbon Britain / Green New Deal 'Scenario' and Jacobson / 100.org 'Roadmaps' laudably wish to reduce the portion of global greenhouse gas emissions by 2050 due to Transport (**15%**) and Aviation (**1.5%**) by replacing UK-based cars with electric vehicles powered by lithium batteries.

When it comes to mass production of hybrid and electric vehicles, the main problem has been a shortage of batteries. And the main material in growing demand is lithium. An element found in abundance in South America, where the cheapest extraction method by evaporating salt brines in the solar ponds deploys usage of cheap and toxic PVC; and in lithium-rich regions of Chile where extracting the metal uses two-thirds of the area's fresh drinking water. [161](#)

To achieve this, the Natural History Museum calculated in 2019 (in an open letter to the Committee on Climate Change) [162](#) that the UK (not including the LGV and HGV fleets) would need just under two times the current total annual world cobalt production, nearly the entire world production of neodymium, at least half of the world's copper production, and three quarters the world's lithium production during 2018. [163](#)



Or to put it another way, ensuring the annual supply of electric vehicles from 2035 will require the UK to annually import the equivalent of the entire annual cobalt [164](#) needs of European industry with at least a 20% increase in UK generated electricity.

Even if we burnt all the fossil fuels needed to extract all the minerals to enable a global 100x growth in the number of electric vehicles to 400 million on the roads by 2040, it would displace only **5%** of global oil demand. Extrapolated to 2 billion cars worldwide, the energy demand for extracting and processing the metals alone is almost 4 times the total annual UK electrical output.

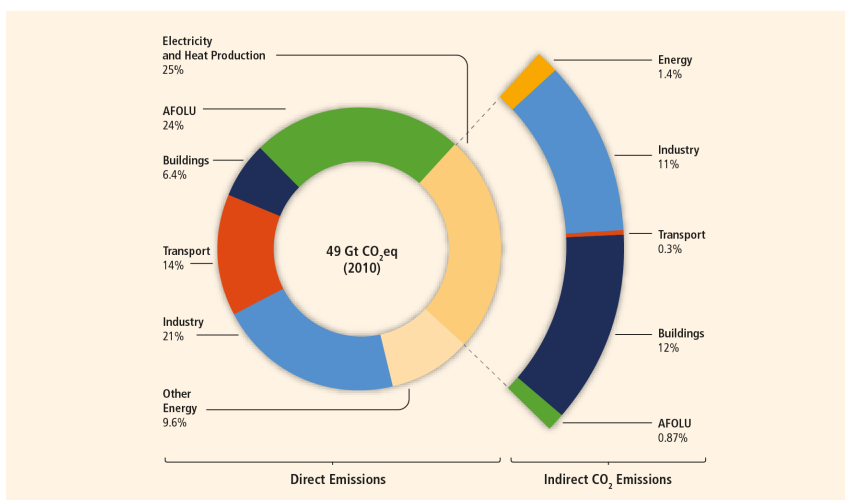
The massive expansions of mining activities demanded by WWS technology increases already severe environmental degradation. [165](#) And the Electric Vehicle industry is now realising scalability is dependent on reliable sources of supply and is waking up to the threat of massive constraints in the future. [166](#)

Its clear WWS technologies do not scale-up well, they soon hit a runaway cycle of constructing more and more renewable plants, causing fossil fuel energy use to rise chasing ever diminishing global supplies of bulk metal resources such as steel, copper, lithium, cobalt, and neodymium, as Google already found out. [167](#) [168](#)

### **15. Externalities Limiting non-Nuclear 100% Wind Water and Solar power**

The ZCB / GND 'Scenario' laudably aims to reduce the UK contribution to global greenhouse gas emissions by focusing on the portions taken by: Buildings (**18%**) reduced by upgrades; Transport (**14%**); Agriculture, Forestry and Other Land Uses (**25%**) which includes livestock at circa (**5.5%**); (IPCC) [169](#) all only yielding very limited scope for reductions.

## Greenhouse Gas Emissions by Economic Sectors



But it fails to emphasise the significant increases in minerals and mining and greenhouse gas emissions necessary with Wind Water and Solar systems in the portion taken by: Energy needed to supply energy (13%); the contributions of Heavy Industry (29%); and Other (10%); [170](#) (IEA, 2012 et al) [171](#) which are largely sidestepped, whilst quietly expecting industrial and domestic energy demand is halved, three quarters of the population become vegetarian or vegan, and yet be able to build & maintain the largest infrastructure project humanity ever envisioned.

### 16. Energy Feudalism, Extractivism, Exploiting the Global South : Renewable Energy = Fossil Fuel+

Assembling the biggest work force in global history devoted to extracting and processing the billions of tonnes of metals and other minerals needed, all mostly powered by fossil fuels, then sequestering all the land and sea bed needed to build and maintain the energy infrastructure transformations conjured up in the Green New Deal / Zero Carbon Britain 'Scenarios' and Jacobson / 100.org 'Roadmaps' (and others) would amount to Energy Feudalism.

It is inconceivable that the additional unnecessary austerity in energy (55% cuts, dressed up as consumer efficiencies), and food (75% cuts, dressed up as health improvements), as suggested by the ZCB / GND 'scenario' will be acceptable to people in the UK. It will be politically impossible to persuade a majority in the UK to voluntarily choose a vegetarian or vegan diet, and then to also reduce their current energy footprint by over a half, whilst living with intermittent electricity power grid failures and cuts in winter.

Even if it were, UK domination of globally limited metal and mineral supplies is not possible at any price.

“When liberals, progressives, “the Left,” and even environmental justice activists applaud the large-scale transition to renewable energy, they ignore the many hazards that would otherwise be unacceptable to them. Displacing fossil fuel industries to the Global South, where there are fewer environmental regulations and political rights, makes possible the use of excessive forms of state-private security violence against anyone who might protest them. Furthermore, the material [minerals, metals & land] necessary for renewable energy can only result in an increase in Extractivism in the Global South and all the negative consequences this entails for people on the ground. If we do not confront these facts, then the solution of today — like previous energy systems and regime changes — will likely result in the complicated tyrannies of tomorrow. Recognizing renewable energy as Fossil Fuel+ is a first step to combat the fairytale of renewable energy. By highlighting the myths surrounding renewable energy, we also create the groundwork for greater environmental considerations and the enactment of radical ecological alternatives that address the roots of consumer society and its marketed solutions.” [172](#)



Pitching even further into the fairytale realm, the Green New Deal and other similar “new energy economy” proposals both in Europe and the US rests on the belief that the technologies of wind, solar power, and battery storage are undergoing the kind of disruption experienced in computing and communications, dramatically

lowering costs and increasing efficiency when they are not, as we have discovered above. Certainly not in the short and medium terms needed to match the urgency of the climate and humanitarian emergency we now face. [173](#)

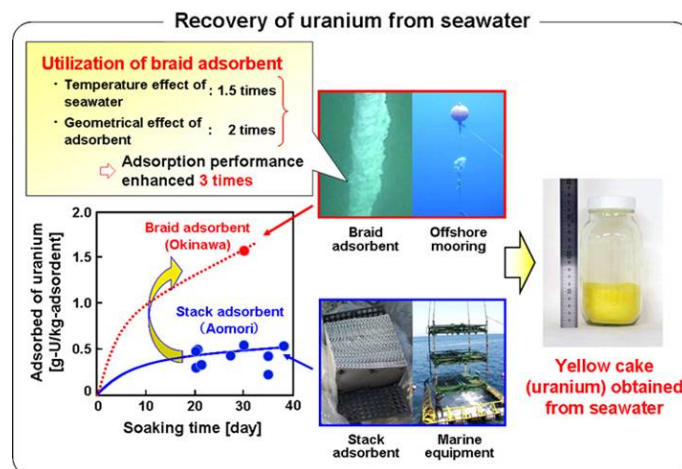
Instead we need more honesty and transparency from leaders and commentators about the true impacts of fear based deeply irrational ideological rejections of Nuclear power in the 'Scenarios' and 'Roadmaps' on offer, such as in this compendium of 'plans' [174](#) (including ZCB & Jacobson etc.) that yet again fails to account for limiting physical externalities, trying to argue that 100% WWS can supply base-load without Nuclear or fossil or adequate storage. Their agenda(s) self evidently rests on overlooking the engineering constraints imposed on 100% WWS technology by the laws of physics, maths, [175](#) and basic ethics, and so we must reject their conclusions as anti-scientific.

## Part FOUR: Nuclear Power : Answering Objections

### 17. Nuclear Power is completely renewable

Nuclear power's raw materials foot print (minerals, metals & land) is thousands of times smaller than WWS because Nuclear has a very high energy density. [176](#) This means future Nuclear power build-out expansion is not limited by any of the scale-up blockages that plague WWS, with its ever increasing demands for more mining & raw materials powered by fossil fuels spiralling out of control.

Uranium (used as fuel for Nuclear power) is now being extracted from seawater by Japanese, Chinese and US engineers, finally ending the shameful historical exploitation of African and other uranium miners. [177](#) [178](#) There's about 4 billion tons of uranium in the ocean at any one time. Whenever uranium is extracted from seawater more is leached from rocks to replace it. The process is controlled by steady-state, or pseudo-equilibrium, chemical reactions between waters and rocks in the ocean and on land. Even if Nuclear provided 100% of our energy, it is impossible for humans to lower the overall seawater concentrations of uranium over the next few billion years, [179](#) [180](#) [181](#) [182](#) if we last that long.



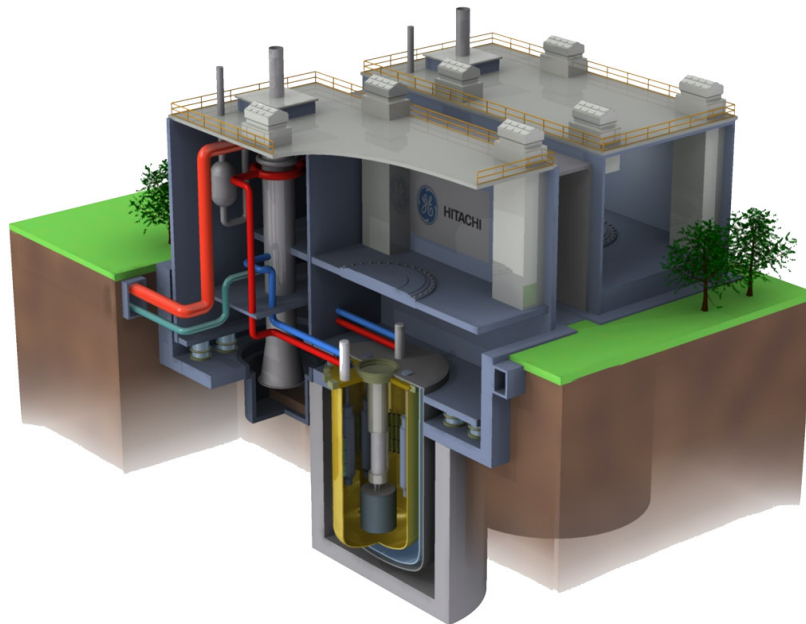
Future Nuclear power build-out is also not limited as some anti-Nuclear lobbyist claim, [183](#) [184](#) by strategic "criticality" [185](#) or availability of rare metals needed to expand Nuclear build-out such as thorium, uranium, hafnium, beryllium, zirconium, and niobium [186](#) [187](#) [188](#) because (as for uranium) recoverable limitless supplies are also dissolved in seawater. [189](#) [190](#)

### 18. SOLVED: Radioactive for 300,000 years 'Wast Storage Problem' reduced to 300 years

The current global fleet of Generation III Nuclear reactors uses only about 2% of the energy in their uranium fuel. The remaining 98% remains in the spent fuel. But new Generation IV reactors can recover all that otherwise wasted energy by 'burning it down' to generate electricity simultaneously rendering it safe as background radiation in 300 years. [191](#) These reactors have multiple passive fail-safe features and are now being built in China [192](#) and will be available with its policy to 'go global' exporting Nuclear technology. [193](#)

### 19. Recycle Generation III Nuclear 'Waste' and Nuclear Warheads as Fuel for new Generation IV Reactors

In the UK in 2006 GE/Hitachi wanted to build such a generation IV reactor design called PRISM with no upfront public plant commissioning costs and income only from selling the electricity generated from 120 tonnes of spent fuel 'waste' (from the current fleet of Generation III reactors) sitting in storage tanks at Sellafield enough for 500 years or so of all UK post-carbon electricity demand. [194](#) [195](#)



In Canada Molten Salt Reactors (MSRs) are building a Molten Salt Reactor (first built in the 1950s) [196](#) designed to generate electricity by using generation III spent fuel waste as fuel, or fresh uranium, or thorium. These 'swamp' reactors can also be designed to 'burn' Nuclear warheads as fuel to generate electricity. [197](#)

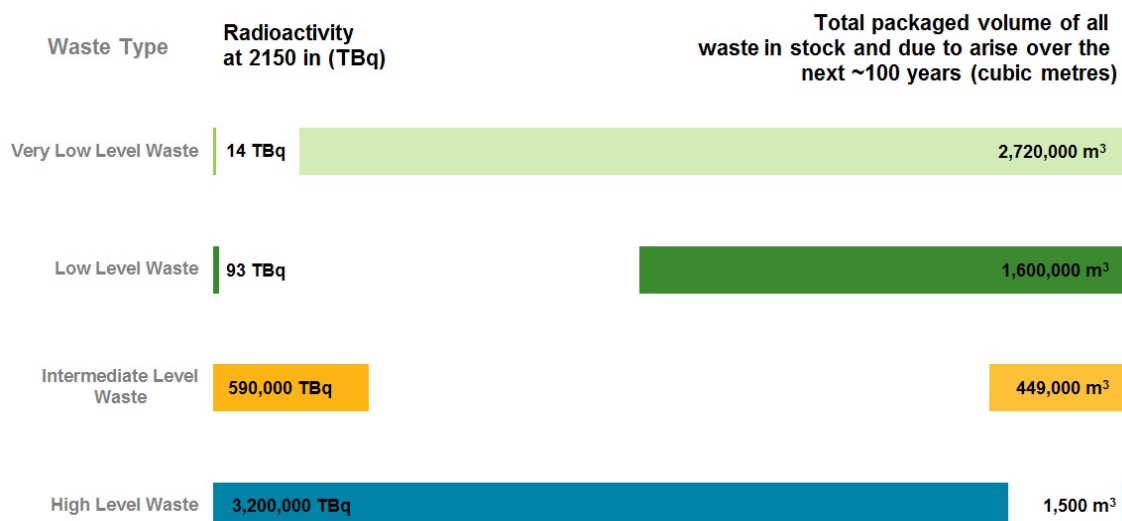
The Generation IV International Forum fourteen members including the UK, US, China, India, Russia, France are pursuing all these solutions and more. The first Generation IV systems are expected to be deployed commercially around 2030-2040. [198](#)

Whilst we wait for politicians to commission these reactors, Finland has taken the lead on the issue and is constructing a permanent underground depository. The project has been supported by the government and, most importantly, by the local community. And for good reason. The science supports the safety of their approach. Spent fuel can be safely stored deep underground in stable rock formations, such as the granite bedrock in which the Finnish site is being constructed. [199](#)

## 20. How much Un-Recyclable Nuclear 'Waste' is there? And what does 'Half Life' mean?

When packaged, the total amount of radioactive waste produced in the UK (including waste in stock and estimated to arise over the next ~100 years) would fill a volume roughly the size of Wembley stadium. [200](#)

More than **90%** of all radioactive waste in the UK is Low Level Waste or Very Low Level Waste, including waste in stock and everything estimated to arise over the next ~100 years. Most of this waste will be produced during the dismantling of existing Nuclear facilities and cleaning up of Nuclear sites. Less than **10%** of all radioactive waste to be produced in the UK will be Intermediate Level Waste and less than **0.03%** will be High Level Waste. (i.e. the 120 tonnes waiting for PRISM reactors to get built and start recovering the remaining 98% of the energy remaining in it).



All machines generate waste, and fission reactors are no exception. Radioactive waste decays to a stable state after some period of time and becomes normal waste. This decay is exponential, so if we create Q cubic meters of new radioactive waste each year, the total amount in existence quickly stabilizes to a constant multiple of Q, which depends only on the half-life of the material. For instance, if the half-life is one year, every year we have  $1Q + 1/2$  the previously existing amount. This quickly converges to  $2Q$ . [201](#)



Low-level waste includes things like metal reactor parts, protective clothing, etc. that becomes radioactive in the course of reactor operation. Typical half life for these materials is 10 years, leading to an equilibrium amount 15 times annual production. [202](#) [203](#)

We need to consider the three different kinds of radioactive materials produced in reactors: actinides, fission products, and low-level waste. Actinides typically have long half lives, but they are not waste. They are fuels that can be separated (reprocessed) and re-used again. This is done on an industrial scale today, in France and elsewhere for Generation III reactors. (PRISM generation IV recycling described above is a different technology entirely).

Fission products have a wide range of half lives. Many decay to stability in seconds. Some are used in medicine. Cs137 and Sr90, with half lives of 30 years, are responsible for the lion's share of fission product radiotoxicity. The steady cumulative amount of these fission products is therefore about 44 times their annual production.

Worldwide, this takes up a tiny amount of space, a maximum of 900 tonnes of these radiotoxic fission products existing at any one time, assuming our current rate of production, barely enough to fill a cube 25 feet on a side. Thermal energy produced from fission was about  $2.765 \times 10^{10}$  GJ in 2009 [204](#) meaning that about 340 tonnes of fission products were created [205](#) of which about 6% was Cs137 and Sr90. So  $44 * 0.06 * 340 = 900$  tonnes.

## 21. Background Terrestrial Radiation – Is it dangerous?

Eating Brazil nuts [206](#) or butter beans or bananas or working as airline flight crew or living in locations with high radiation levels [207](#) increases your annual dose rate. [208](#)

For example Kerala's monazite sand (containing a third of the worlds radioactive thorium) emits about 8 micro Sieverts per hour of gamma radiation, 80 times the dose rate equivalent in London, but a decade long study of 69,985 residents published in Health Physics in 2009: "showed no excess cancer risk from exposure to terrestrial gamma radiation ... indicating no statistically significant positive or negative relationship between background radiation levels and cancer risk in this sample." [209](#)

## 22. Chernobyl: Europe's Largest Wildlife Refuge

Visitors to the 30 kilometre radius exclusion zone will get more radiation from the flight they take to get to a guided tour. According to biologists, far from a Nuclear wasteland, the exclusion zone has become a sanctuary for flora and fauna - precisely because people were forced to flee. [210](#) [211](#) National Geographic "30 Years After Chernobyl, Nature Is Thriving." [212](#) BBC "The Chernobyl exclusion zone is arguable a nature reserve." [213](#)



The problem is that at the very low doses found in the exclusion zone, its practically impossible to correlate any irradiation with certain biological effects. This is because the baseline cancer rate is already very high with the risk of developing cancer already fluctuating **40%** because of individual life style and environmental effects, obscuring the subtle effects of low-level radiation. Secondly, and this is crucial, the truth about low-dose radiation health effects still needs to be discovered. It's still not exactly known whether these low doses of radiation are detrimental or beneficial nor where the thresholds are. [214](#) [215](#)

Nonetheless, anecdotal evidence suggests that women who stayed in the exclusion zone have generally outlived their neighbours who stayed away, "happiness" — or relative happiness, anyway — is a key reason

why. About 100 people live there now, the last remnants of more than 1,000 mostly older women who moved back into the exclusion zone in the weeks and months after the disaster. [216](#)



The disaster caused circa 50 direct deaths plus a few thousand early deaths from cancer above the 100,000 expected deaths in the exposed population. [217](#) [218](#) [219](#) But tragically, it was very preventable and the result of decision-makers' hubris and bad policy that encouraged shoddy practice. The design of the reactors were significantly flawed with a well known "built-in instability". An early Generation II reactor based on 1950s Soviet technology, the RBMK design was optimized for speed of production over redundancy. The combination of graphite moderator and water coolant is found in no other power reactors in the world. [220](#) [221](#)

### **23. Fukushima : Radiation less than a Banana and below detectable levels**

It has long been asserted that nuclear reactor accidents are the epitome of low-probability but high-consequence risks. Understandably, with this in mind, some people are disinclined to accept the risk, however low the probability. Let them be reassured: Chernobyl, Fukushima, and Three Mile Island are the only major accidents to have occurred in over 17,000 cumulative reactor-years of commercial nuclear power operation in 33 countries. The global fleet of Nuclear reactors all now have massive concrete containment buildings, and multiple fail-safe operator independent systems making the chances of another Chernobyl style accident vanishingly small. [222](#)



Two years after the tsunami and meltdown at Fukushima in 2011, the World Health Organization reported in 2013 that residents who were evacuated were exposed to so little radiation that radiation-induced health effects were likely to be below detectable levels. [223](#) [224](#) Evacuated residents are now returning. [225](#) The amount of radioactivity typically reported in wildlife in the Pacific Ocean blamed on Fukushima is less than that found naturally in a banana. [226](#) [227](#)

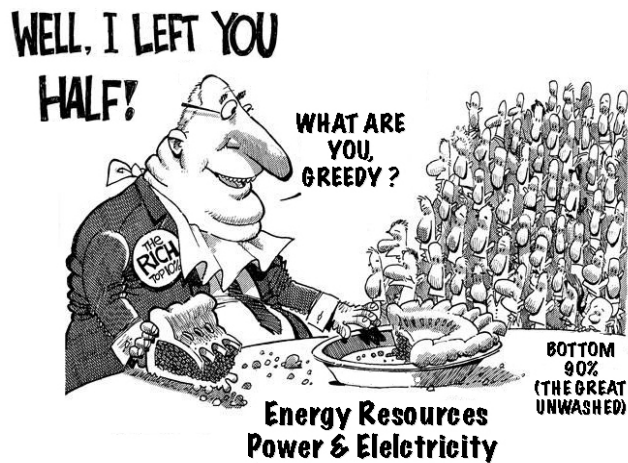
### **24. Nuclear Weapons Proliferation risks not increased by Nuclear Power technology**

As long as there are physics, maths and engineering textbooks, the Nuclear proliferation problem will not go away, or lessen even if there are no civilian power reactors. All the technical knowledge to start a Nuclear weapons program can be found in physics and engineering text books. Nations that have developed Nuclear weapons without authorization under anti-proliferation treaties, have done so without possessing civilian Nuclear power industries. For example South Africa demonstrated that a limited number of Nuclear weapons could be built from scratch very cheaply. [228](#)

## **Part FIVE: CONCLUSION – A Call For Immediate POLITICAL ACTION – NOW!**

### **25. Harmony a 'plan that adds-up' for future Electricity Generation : 75% Renewable plus 25% Nuclear**

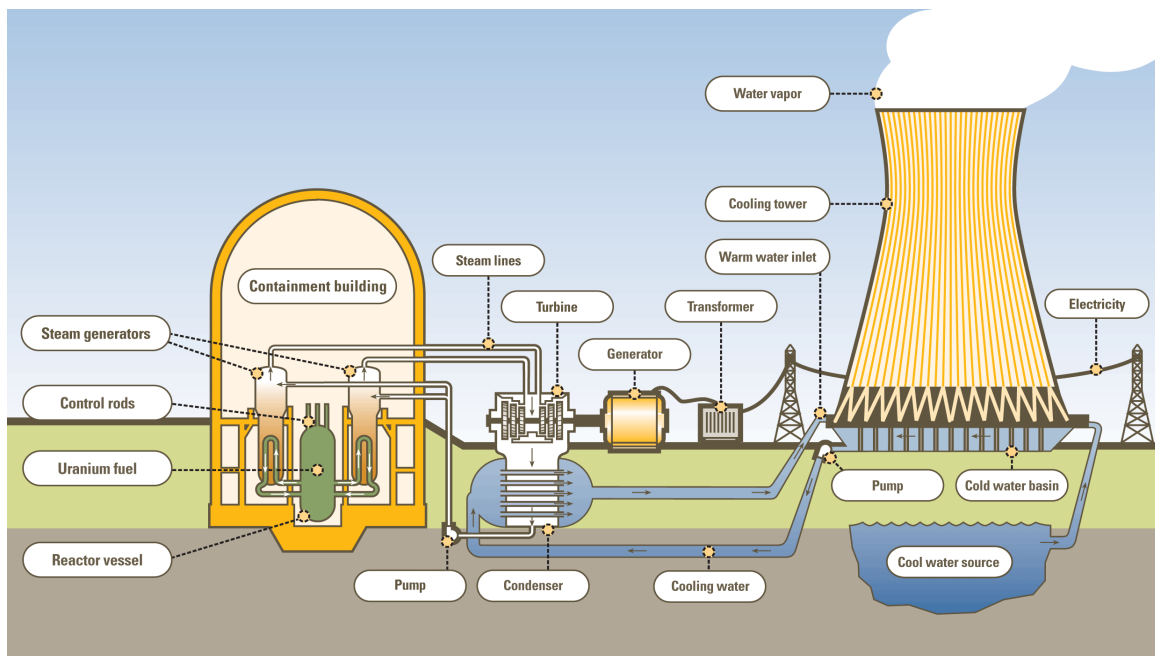
By every humane measure, the world needs more energy. Energy multiplies human labor, increasing productivity. Global energy demand will likely double in the next 50 years and may double again in the next 100 years as world population increases and people seek to improve their standards of living. [Royal Society (1999), p. 3.]



For the Wind Water and Solar sectors to penetrate over the coming decades from its present delivery of circa 5% of global energy consumption, and begin to displace fossil fuels' circa 85% share of global carbon emissions, will require massive interventions by private corporate and state actors as well as all the help the 'modern renewable' WWS sectors can get from the Nuclear power sector.

The World Nuclear Association has developed such a shared vision for the future of electricity based on the IPCC 2-degree scenario called 'Harmony' [229](#) whereby WWS expands to supply 75% of global electricity by 2050 and Nuclear energy expands to 25% together forming part of a diverse mix of available low-carbon generating technologies which are deployed in such a manner that the benefits of each are maximised while the negative impacts are minimised. In this optimised energy system the needs for societal development and prosperity are mindfully balanced against those of the natural environment.

Nuclear energy is proven, available today and can be expanded quickly, making it an important part of the solution. [230](#)



## 26. Energy supply is most efficiently configured as a state owned & controlled 'Natural Monopoly'

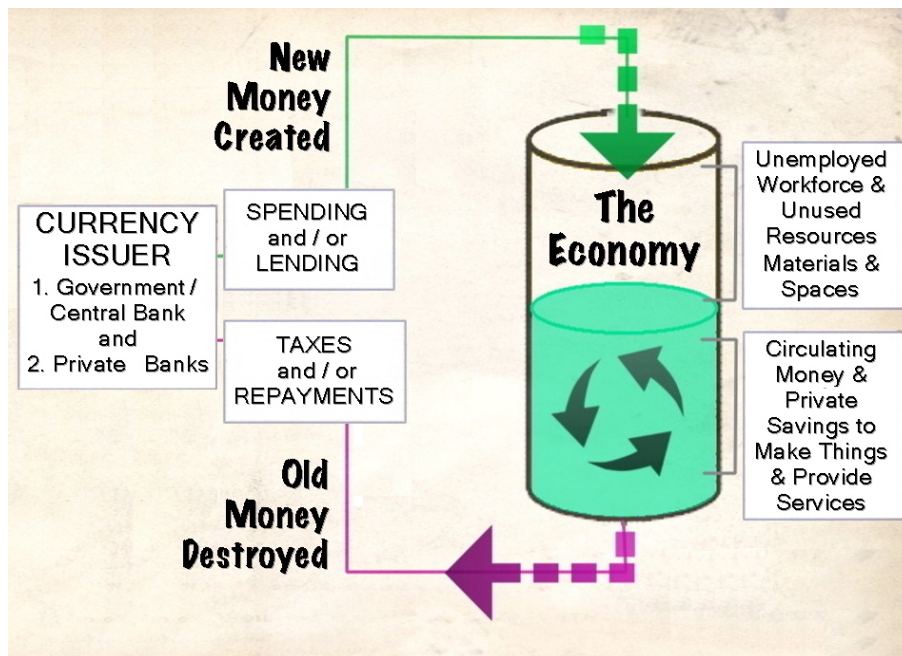
Complaints the private Nuclear power sector always suffer financial losses [231](#) [232](#) miss the point: all energy infrastructure is a 'Natural Monopoly' i.e. its a utility with very high fixed costs meaning its impractical and inefficient and more expensive to have more than one publicly owned firm like water, sewer, or railway services. [233](#) [234](#) A natural monopolist can produce the entire output for the market at a cost lower than what it would be if there were multiple firms. A natural monopoly occurs when a firm enjoys extensive economies of scale in its production process. [235](#) All the proposed 'plans' for non-Nuclear 100% Wind Water Solar are also 'plans' to formally set up functioning state owned 'Natural Monopolies', whether they explicit admit it, or even realise it, or not.

For example, WWS can only claim to undercut Nuclear power on end-user prices when the overall costs of intermittency, storage, and environmental damage, such as mining of raw materials and its hidden reliance on fossil energy, and excessive land use are excluded.

## 27. It is just as nonsensical to say we have run out of kilograms as to say we have run out of money.



Publicly created brand new money to build state controlled / owned 'Natural Monopoly' infrastructure partnerships between the Nuclear and WWS sectors is, and never will be, a scarce resource. The energy to build such infrastructure is scarce. Labour, and fossil fuels, and minerals, and metals, and clean water are all scarce. And political will to do the right thing is scarce. But money is not. Money can be and is created with a keystroke.



Money is only numbers on spread sheets that simply measures and balances those scarce resources. The plain brutal fact is that money is only an accounting identity. It allows dealings to be consummated. A measuring ticket of a deed done. It is the blood of human exchange. It is bookkeeping by electricity.

It is just as nonsensical to say we have run out of kilograms as to say we have run out of money. This is true in both the public and private sectors. The private sector creates brand new money every time someone takes out a loan. In the public sector the government finances itself through money creation because for all intents and purposes, the treasury and central bank act together. [236](#) This happens every day and is nothing new. [237](#) [238](#) Most common assumptions on how banking works are simply wrong, with even the Bank of England in 2014 throwing out of the window any residual theoretical basis for "austerity" based on deceitful claims by some governments that "we've run out of money." [239](#)

## 28. Global cooperation - achieving Harmony

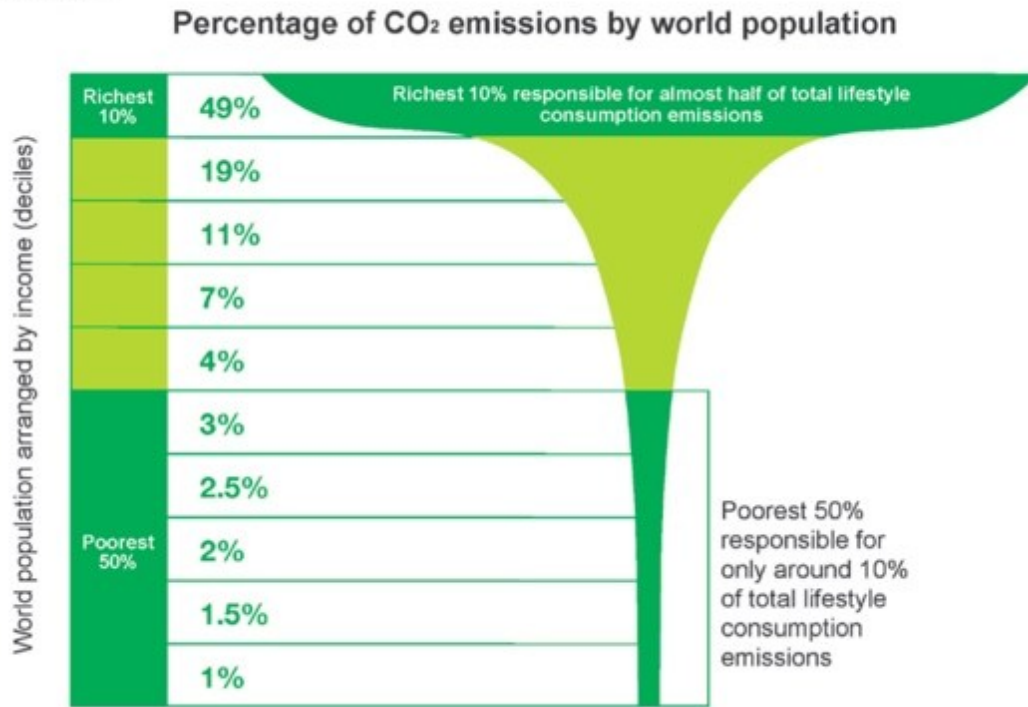
For Nuclear to grow from supplying **11%** of global electricity today to **25%** in 2050 (i.e. grow from **2%** of global energy supply, to, say an optimistic **8%** due to increased electrification expected by then) will require roughly 1000 GWe of new Nuclear capacity to be constructed - depending on other factors like reactor retirements, electricity demand growth etc. These targets may seem underwhelming to some and far-fetched to others, but a great deal of consideration has gone into them.

Note these targets do not rely on the expected commercialisation of any advanced Generation IV reactor designs (discussed above). A quarter of electricity generation easily fits within the baseload profile of most countries and this could readily be met by currently available reactor designs. [240](#)

## 29. Progressive Political Support NOW : 75% WWS plus 25% Nuclear Electricity Generation the 'Ultimate Power Couple'

To be credible voices in the policy space opening up earlier in 2019 following the UK parliament's [241](#) global lead in being the first to declare a "Climate Emergency" [242](#) this paper calls on all anti-Nuclear power actors and environmentalists across the progressive political spectrum in UK politics, such as members and supporters of the Green Party, the Labour Party, the Green New Deal group, Friends of The Earth, and Greenpeace to now fully accept the scientific consensus and join their colleagues some of whom are listed above, in letting go of their anti-Nuclear stance and acknowledge that not only is Nuclear power is the safest of all electricity generation technologies, [243](#) but that it can also begin to make energy poverty history by ensuring greater equality of energy access for all.

**Figure 1: Global income deciles and associated lifestyle consumption emissions**



Source: Oxfam

Externalities enjoyed in the developed world, in particular the historical infrastructure advantages, all won largely on the back of Big Fossil's toxic persistent and deadly ever expanding emissions over the last few hundred years, must not be ignored or made invisible in our deliberations and actions. Do we deny much of the rest of the global population - **12%** of humans who are off electricity grid entirely nearly 1 billion people and 3 billion people using less electricity than a refrigerator - access to abundant energy because some of us now enjoying these infrastructure advantages have adopted a false "austerity" rhetoric?

But in defence of what? When Nuclear power can provide for every human beings' needs more equally and reduce energy access inequality more efficiently by every metric we care to apply? Ignoring such day to day / historical advantage is both anti-scientific and thus immoral so we must reject it in favour of Nuclear power as quickly as possible for the many not the few. This is just being fair.



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In particular to recognise that the only technical, and politically possible way - at the pace now required - to equalise the global energy system whilst simultaneously decarbonising it, is to admit the Nuclear power sector as an essential renewable and low-carbon supporting part of the UK electricity energy generation mix, together with the Wind Water & Solar power sectors in a mutually enabling partnership to achieve the Green New Deal aim "to power a renewables revolution" and "create thousands of green-collar jobs."

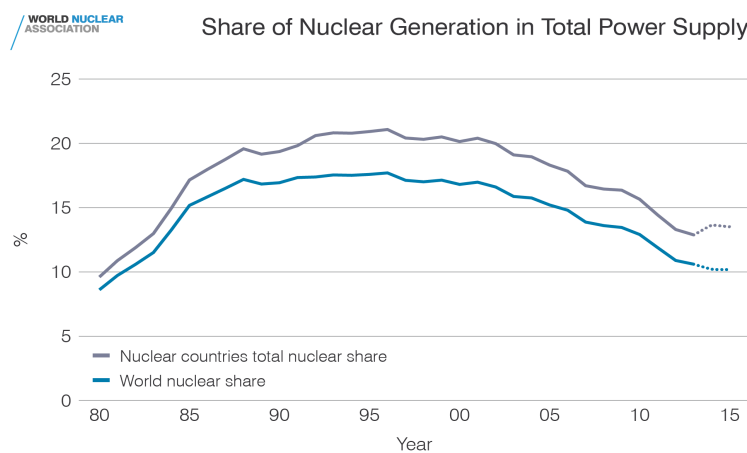
Fossil fuels will be needed for a very long time so we should preserve fossil reserves for future generations vital non-fuel uses, not selfishly burn them building and maintaining impossibly inefficient 100% WWS electricity generating systems. In 2017, about **13%** of total petroleum products consumed were for non-combustion but vital non-fuel uses, such as construction materials, chemical feedstocks, plastics, lubricants, solvents, waxes, natural gas used in fertilizers, and many other products. [244](#)

The stone age did not end because humanity ran out of stones, and neither will the fossil fuel age with a plan that adds up."

The most dangerous Nuclear power station is the one that doesn't get built. [245](#) When Nuclear plants aren't built, or are shut down, fossil fuels are burned and people will needlessly die. [246](#)

- Per kilo-watt hour of power generated : Natural Gas kills 38 times as many more people as Nuclear Power; Biomass 63 times; Petroleum 243; and Coal 387 times as many, perhaps a million globally a year (p147). [247](#)
- Energy sector related accident fatalities : global average deaths/millionGWhr: Coal (170,000); Oil (36,000); Biofuel/Biomass (24,000); Natural Gas (4,000); Hydro (1,400); Solar rooftop (440); Wind (150); Nuclear worst case estimates (90); Chernobyl (total direct deaths 47); Nuclear – commercial power plants only rest of the world (0). [248](#)
- In equivalent lives lost per gigawatt generated annually : Coal = 37; Oil = 32; Gas = 2; Nuclear = 1 (i.e. loss of life expectancy from human exposure to pollutants) [IAEA (1997), table 4, p. 44.] [249](#)

Compared to Nuclear power, in other words fossil fuels and Wind, Water & Solar renewables, have all enjoyed a free ride with respect to protection of the environment and public health and safety.



Source: IEA, World Energy Outlook 2014; IAEA PRIS; World Nuclear Association (for 2014-15 data)

Progressive Political forces in the UK and globally MUST now be courageous and call for an immediate reversal in the decline in Nuclear power's share of global electricity and energy supply in the fight to do away with energy poverty and eliminate greenhouse gas emissions, by FULLY and LOUDLY embracing the ALL the following policy options:-

1. The pro-Nuclear electricity generating mitigation scenarios given in the IPCC 2018 Special Report [250](#) (SR15); and
2. The **75%** Wind Water & Solar renewable power plus **25%** Nuclear energy balance as set out by the World Nuclear Association in its 'future of electricity' Harmony [251](#) vision; and
3. The Confederation of British Industry July 2019 press release [252](#) [253](#) urging government to prioritise new Nuclear electricity generating power stations in the UK.

Ends

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[13](#) Natasha graduated in 1982 specialising in 3D design, and worked in industry designing spiral staircases, and high end audio (vacuum tube, horn speaker & vinyl turntables) she has written & filed 2 patents, rebuilt a 5 storey terraced house, is a secondary, further & higher education teacher, special educational needs (EBD & ASD), was diving officer at University of Brighton Sub Aqua club for a decade, and worked as a whale shark spotter at Ningaloo reef during 1 year tour of SE Asia's wrecks & reefs. In 2001 she completed a Post Graduate Diploma, Business Research, (first of two year MA Change Management), University of Brighton, through out the early 2000's active in Brighton's multi agency Home Office funded Anti Victimisation Initiative (AVI), participated in University of Brighton 'Count Me In' research, wrote and won several high profile employment tribunal cases supported by (former) statutory body (EOC), in 2007 helped set up Transition Town Brighton, in 2011 helped Occupy Brighton. Since 2014 she's been advocating for local people the ASD spectrum, helped secure local authority housing and written and won disability (PIPs & ESA) appeals. In 2015 Natasha completed the University of Cumbria MA equivalent online (MOOC) course Money & Society. Since 2013 Natasha's been running a local electronic musicians collective, that regularly puts on synthesiser jams and DJ gigs. <https://www.meetup.com/brighton-electronic/> and <http://www.mixcloud.com/Prisss/> and <https://iflas.blogspot.com/2014/12/money-and-society-mooc.html>

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